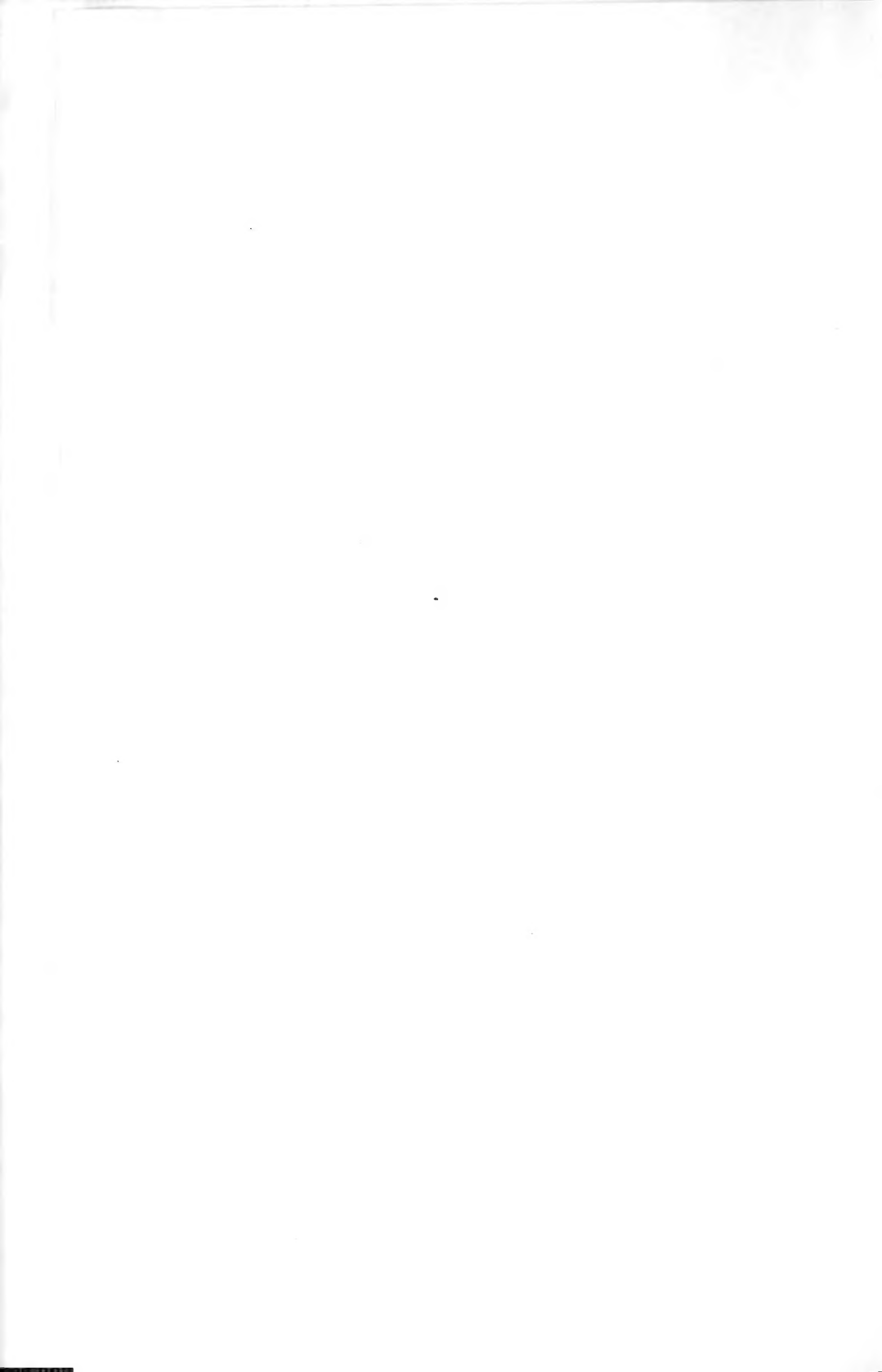




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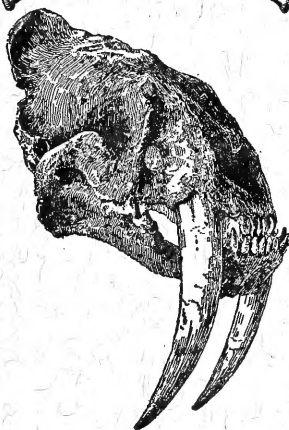




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Mostra tuemur ipsi.



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NOTE ON A HYÆNARCTID BEAR FROM THE MIDDLE PLIOCENE
OF CHIHUAHUA, MEXICO

By CHESTER STOCK

The continental deposits exposed along the margins of the Valley of the Rio Papigochic, western Chihuahua, Mexico, have yielded a large and varied mammalian fauna of the Hemphillian stage of the Pliocene. Elements of the fossil assemblage have been described, and an extended report by Dr. John F. Lance on the fossil horses of the region is now in press.

At least two locality names have been applied to the Chihuahuan middle Pliocene occurrences. Rincon was the first designation and was replaced subsequently by Yepomera, a more desirable place name for this faunal horizon, particularly because Rincon had been used for a stratigraphic formation or member. From the Yepomera Pliocene is now recorded a hyænarctid bear.

HYÆNARCTOS CF SCHNEIDERI Sellards

The description of the material is afforded principally by two upper molars, M1 and M2, No. 3533 Calif. Inst. Tech. Vert. Paleont. Coll. shown in Plate 1. The specimens were collected in the Arroyo Huachin, at Rincon, Chihuahua, locality 275, Calif. Inst. Tech. Vert. Paleont.

Comparison of the Chihuahuan specimen with known North American species of the genus is based on M1. This tooth in No. 3533 is similar in size to that of *Hyænarctos schneideri* from the Bone Valley Pliocene, Florida. According to Frick¹ the latter tooth came from the same excavation at Brewster, Florida, that yielded the type mandible of *Hyænarctos schneideri*. No. 3533 is slightly smaller than the comparable tooth in *H. gregoryi* Frick from the Mt. Eden beds of California. These relationships in size are shown by the following comparative measurements of M1.

	Chihuahua	Florida	California
Anteroposterior diameter	28.6	29.8	30.6
Greatest transverse diameter...	29.6	30.2	32.2

In No. 3533 a cingulum is feebly indicated along the outer side. A well defined ledge occurs, however, in front of the base of the paracone. The crown narrows very slightly anteriorly in transverse width. This tooth bears three roots of which the inner is by far the largest. Of the two roots above the outer half of the crown, the posterior is larger than the anterior.

¹Frick, C., The Hemicyoninae and an American Tertiary bear. Bull. Amer. Mus. Nat. Hist., vol. 56, art. 1, fig. 26a, pp. 63, 75, 1926.

Fortunately, M2 of each side is present. This is the first time that the second upper molar of a North American species of *Hyænarcos* has become available, thus permitting comparison with Old World forms. As in M1, the crown of M2 bears three roots, and the inner root is the largest of the three. The crown contracts in transverse width across the metacone, and expands in anteroposterior diameter behind the hypocone to form a small talon. The latter projects slightly farther backward than in M2 of either *H. sivalensis* from the Siwalik beds of India or *H. insignis* from Montpelier, France. It is not at all so well developed as in the Indian or American species of *Indarctos*.

The external cingulum is better developed at the base of the paracone in this tooth than in M1. The ridge forming the protocone is long; the hypocone is a small, but distinct cusp. A cingulum is present along the base of the protocone.

Measurements (in millimeters) of M2 in No. 3533 are: anteroposterior diameter normal to anterior side and parallel to inner border 27.5; greatest transverse diameter normal to inner side and across paracone 31.4.

The present material represents the second occurrence of hyænarcetid bears known from the later Tertiary of Mexico. Freudenberg² figured and described a large lower carnassial from the brown coal of Tehuichila near the boundary between the states of Hidalgo and Vera Cruz. Freudenberg² thought the specimen resembled *Hyænarcos*. Frick referred this tooth to the latter genus. While the tooth is 5 millimeters longer than that in the type of *H. schneideri*, it is only a trifle wider.

Contribution No. 542,
Division of the Geological Sciences,
California Institute of Technology.

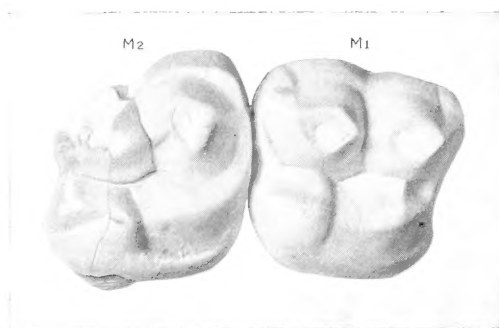


PLATE 1

Hyænarcos cf. *schneideri* Sellards. No. 3533 Calif. Inst. Vert. Paleont. Coll., right M1 and M2, occlusal view, natural size. Yepomera, Middle Pliocene, Chihuahua, Mexico.

²Freudenberg, W., Geol. u. Palæ. Abhandl., N. F., vol. 9, p. 205, pl. 3, fig. 2, 1910.

FOSSIL ARTHROPODS OF BRITISH COLUMBIA

By W. DWIGHT PIERCE

5. A NEW DEPOSIT OF LIGNITE

On September 1, 1949, Mr. Walter MacKay Draycot presented the writer with a lot of black shaly Interglacial lignite, much more solidly compressed, consisting of plant material with almost no fine silts, as compared with that from Lynn Creek. It was collected along the Seymour River which enters Vancouver channel just east of Lynn Creek; at a point 8 miles from the mouth and at an altitude of 450 feet.

One of the characteristics throughout this shale was the large number of shining black seeds, resembling insect chitin, and entirely different plant remains from those in the Lynn Creek lignite. These will be reported on later by a paleobotanist.

A few insect remains were obtained, and will be considered in this series of articles.

6. FOSSIL SPIDER SILK

The most surprising find of all in the Seymour River lignite was five little silken egg cases, and I was inclined to think that these might be the oldest examples of silk in existence, until I read Dr. McCook's chapter on "Ancestral Spiders and Their Habits, in his great monograph on "American Spiders and Their Spinning Work," 1890 (vol. 2:446-469), in which he cites eleven specimens of cocoons from the Oligocene shales of Florissant, Colorado; Green River, Wyoming; and Quesnel, British Columbia. These had been given the name *Aranca columbiæ* Scudder (1878), which McCook in 1880 assigns to the Theridiidæ, and Scudder (1890) agrees. These were oval in shape and most of them hung by a pedicel.

Following the Scudder plan the new cocoons are named in a general genus to indicate the probable family.

SALTICUS SEYMOURI, new species

Five silken cocoons, semi-lenticular, cut straight across and open on that side; measuring 4.16×3.0 mm., 3.52×2.40 mm., 3.84×2.56 mm., 3.28×2.4 mm., and 3.04×1.92 mm. Two of them contained round masses, probably crushed eggs. The silk is very closely woven, and of a creamy or straw color. My assumption is that the spider remains in the case with her egg ball. The case does not consist of two layers united at edges, but is a one piece pocket sac, open at one side, and hence most likely to belong to a small Salticid. The Gnaphosidæ and Thomisidæ make lenticular cases with the two layers united at the edges.

7. A CARABID FROM LYNN CREEK LIGNITE

A fine pair of elytra belonging to the genus *Notiophilus* was recovered from Interglacial lignite, collected along Lynn Creek, North Vancouver, British Columbia, by Walter MacKay Draycot in October 1946. These elytra had such characteristic sculpture that I felt there could be no doubt as to their generic position, but was three years in discovering that.

The genus *Notiophilus* belongs to the North Temperate Regions and in America occurs as 17 species, most of which are unicolorous. Three species have a yellowish to brownish longitudinal vitta, which also characterizes these new elytra.

H. C. Fall monographed the genus in *Psyche* 13:79-92, in 1906; and Thomas Lincoln Casey reviewed it in *Memoirs on the Coleoptera* 9:139-143, in 1920. These texts leave only *N. sylvaticus* Eschscholtz, *N. nemoralis*, Fall, and *N. semiopacus* Eschscholtz with which to compare our specimens. The first two are characterized by a broad and entire yellow lateral vitta occupying the lateral interstriae; and *semiopacus* has a dull lateral vitta, which may be entire, or distinct only toward the apex. Fall does not give any cue of difference in sculpture or texture of the vitta from the remainder of the surface.

The only other character by which an elytron in this genus can be determined by keys or descriptions, is the number of annulate setigerous punctures or foveae near the apex of the elytra. No mention is made of the presence of such punctures elsewhere on the elytra, although they are present in the various species of the genus.

N. sylvaticus and *N. nemoralis* have two such punctures or foveae near the apex, and *semiopacus* has three, rarely two or four, while the new species has six or seven more or less discernible annulate punctures near the apex, and in addition has three at the base, and five others scattered on the disc. Since *semiopacus* is the only species with more than two apical punctures, the new material was compared with California specimens, and is unquestionably different. In *semiopacus* there are two short diagonal striae joining the sutural stria. In *vancouveri* these striae are abbreviated, the first to two punctures, the second to four and a basal annulate vitta. Furthermore the surface of the elytron in *semiopacus* is not deeply wrinkled in the vitta, but of same surface level, although the sculpture is reticulate around all striae and smooth in the radial and cubital areas.

Checking from distributional standpoint, *N. nemoralis* is known only from New England; *N. sylvaticus* occurs in the coastal belt from Southern Mendocino County, California, through Oregon, Washington, Vancouver and British Columbia, to Sitka and Kenai, Alaska, from sea level to over 5000 feet on Mt. Rainier. *N. semiopacus* occurs in Oregon and California to

San Diego. The two Western species are readily separated by frontal characters, which of course are not available to us. On present evidence then, *vancouveri* is a distinct species belonging near *sylvaticus* and *semiopacus*.

NOTIOPHILUS VANCOUVERI new species

Described from a pair of elytra from Interglacial lignite from Lynn Creek, North Vancouver, British Columbia, found by Walter MacKay Draycot. Length of elytron 3.40 mm., breadth 1.00 mm. Color shining black with a brownish median vitta arising basally in the cubital area, at the center of the disc including all medial and cubital striae, and at apex reaching radial striae. Texture of the black areas shining smooth; of the vitta, soft, longitudinally wrinkled, minutely reticulate, and much thinner than the black areas.

A characteristic of *Notiophilus*, *Leistus*, *Nebria*, and *Pelophila* is that the elytra are margined at base. This character has not been correlated with modern morphology.

The so-called basal margin is the *plica basalis* or basal fold of Snodgrass, and extends from the base of radius to the vannal fold. It is usually concealed by the prothorax. In this material the axillary region is a broad basal margined band, representing the second axilla, behind which is the third axilla to which vannus and jugum are attached. The first axilla, to which the costa is attached, is seen only on the underside. In the dorsal view (Plate 2, figure 1) just a narrow portion of the vannus, which clasps the body, can be seen.

The costa is only glimpsed at base above (Plate 2, figure 1), but beneath, it extends as a reinforcing brown rib to the apex (Plate 2, figure 3); while the subcosta forms the sutural margin and is black.

The radius is a punctate stria against the subcostal rim. Two short radial veins, R_2 and R_3 are represented by 2 and 4 punctures and R_3 has an annulate puncture at base. The radial interspace is broad and smooth, impunctate and as wide as the entire medial and first cubital area, which in the center is colored brownish. The first four longitudinal punctate striae, which were called by Fall striae 4, 5, 6, 7, constitute the four branches of medius, with a basal annulate puncture separating the first two (M_1 , M_2) from the last two (M_3 , M_4). M_2 has two discal annulate punctures. Three cubital striae are present. The first two include the base of the brown vitta and extend to the impunctate apical area; first cubital has an annulate puncture at middle; the third cubital is indicated basally by a few punctures and an annular puncture, and thence is faintly indicated by punctules on the otherwise smooth cubital and cubital-postcubital interspace. Postcubitus arises from a basal annular puncture and has another near base, and extends at the edge of the vannal fold to its terminus.

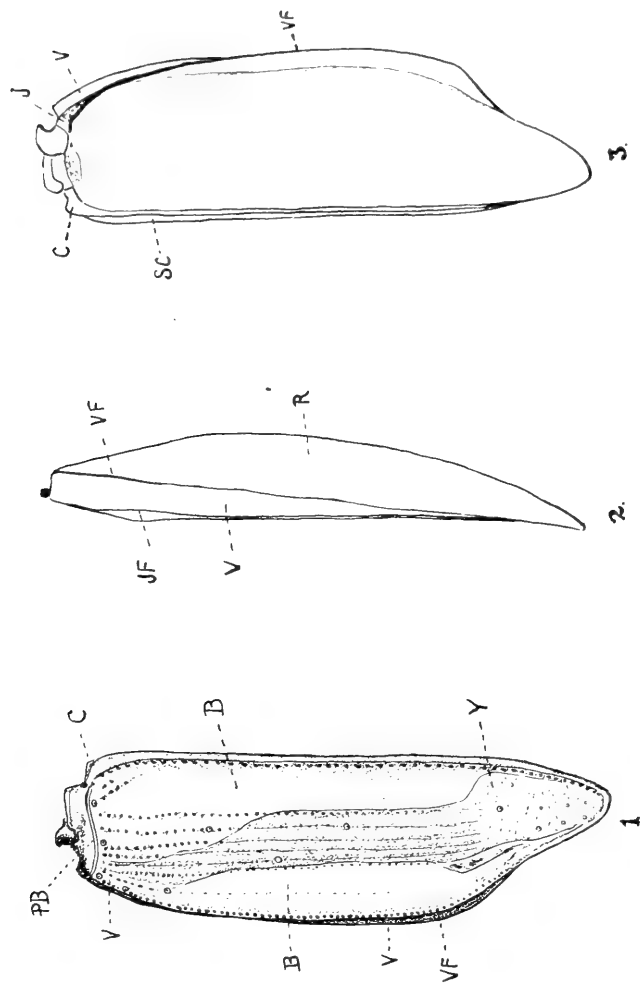


PLATE 2

FIGURE 1. *Notiphilus vancouveri* Pierce, dorsal view of left elytron. B—smooth shining black; Y—soft, reticulate brown. C—costa; PB—plica basalis; V—vannus; VF—vannal fold.
 FIGURE 2. The same, lateral view. JF—Jugal fold; R—remigium; V—vannus; VF—vannal fold.
 FIGURE 3. The same, under side. C—costa; J—jugum; V—vannus; VF—vannal fold.

Hence in the old terminology the elytron is 11-striate with the 2nd, 3rd, and 10th abbreviate.

The apical fourth of the elytron in the brown soft zone is more or less smooth, with one large and three faint annulate punctures representing first medius and three representing fourth medius (Fall's 7th stria).

The vannus is vertical, broadest in basal fourth (Plate 2, figure 2), and thence gradually narrowing to its terminus at about apical tenth. A tiny infold at base beneath represents the jugum, which very narrowly folds over the edge of vannus as shown in Figures 2, 3.

8. THE GENUS DONACIA IN BRITISH COLUMBIA LIGNITE

T. D. A. Cockerell in 1927 described *Donacia connelli* from Cordova Bay lignite, but since then Mr. Draycot has found much material in the genus.

The beautiful, graceful beetles of the genus *Donacia* in the Chrysomeloidea, occur upon the leaves and stems of water lilies, arrowhead, pond-weed, skunk cabbage, pickerel weed, reeds, sedges, and other water-loving plants, and hence are semiaquatic in habit. The larvæ live on the outside of the submerged roots and obtain their air through the tissues of the host plant. When ready to pupate they enclose themselves in silken cocoons attached to the plant.

This genus is characteristic of Interglacial lignites across North America, and the writer has much material on hand for future reports from other areas.

DONACIA (DONACIA) DRAYCOTI new species

Received November 1, 1946 from Walter MacKay Draycot, collected in banks of Lynn Creek, North Vancouver, B. C., in interglacial lignite.

Holotype (LC 74), three fragments of a brilliant blue green elytron; length about 4.7 mm., width 1.68 mm.; ratio 2.809:1. Striæ (ten in number) consist of elongate punctures, but striæ not impressed, separated by 0.12 to 0.14 mm.; transverse wrinkles very close, short, continue across striæ, anastomosing, and curving; both marginal interspaces smoother. On under side punctures represented by oval tubercles, wrinkling less evident; ten rows of tubercles are distinct.

In addition Mr. Draycot obtained material in 1945, 1946, and 1947; and on September 1, 1949 the writer visited Mr. Draycot, accompanied by Mrs. Pierce, Mr. Carroll Lang, and Miss Ruth Scherfee, and we were joined by Dr. John E. Armstrong, and his assistant Mr. W. L. Brown of the Geological Survey of Canada,

the party picking up considerable matrix from which further material was obtained.

The brilliant blue fragments of this species were found in all lots received; and the paratype series consists of fragments Numbered LC 4, 9, 11, 12, 13, 15, 17, 19, 20, 21, 22, 23, 24, 25, 28, 66, 70, 78, 105, 112, 120, 141, 143, 145, 148, 152, 158, 162, 169, 174, 197, 206, 211, 213, all of a brilliant deep blue to bluish black. But there were other specimens with identical sculpture, which must be considered as black, and these are also included as paratypes of *draycoti*, numbered LC 5, 6, 10, 18, 26, 27, 31, 63, 84, 88, 93, 113, 142, 164, 166, 168, 191, 210, 220.

The elytra are characterized by ten striae rows of punctures, which are so obscured dorsally by the dense, irregular transverse rugosity that they are easily overlooked. These transverse ridges are short, anastomosing with those of other lines, and exist several between successive punctures of the striae. There is no definite pattern to them. The pleurites of the specimens with blue elytra are black.

DONACIA (DONACIA) CORDOVÆ, new species

When Dr. Cockerell described in Canadian Entomologist (59: 303-304, 1927), the discovery of the deposit of interglacial lignite at Cordova Bay, near Victoria, Vancouver Island, he described *Donacia connelli* with elytra smooth between striae, and referred other material to *D. pompatica* Scudder, of Scarboro, Ontario interglacial lignites, which is described as having punctured striae rather deep, and the whole surface transversely wrinkled at the punctures; color bluish purple, deep violet, or dark metallic green. The writer has not seen Cockerell's Cordova Bay material, but has four fragments of a *Donacia* taken by Walter MacKay Draycot, from the same site. These do not in any wise fit either the description or the Scudder illustration of *Donacia pompatica*, but are rather of the type of *D. draycoti*.

The holotype of *D. cordovæ* (CB5) is a pair of elytra, crushed on the matrix, color bluish purple; length 6.0 mm., breadth of single elytron 1.76 mm.; ratio of length to width 3.409:1. The outer margin of the elytra is bright metallic green. While striae punctures can be detected, they are obscured by the more prominent transverse wrinkling.

Paratype CB 7 and CB 8 are fragments of the same type of elytron with identical coloring; while paratype CB 6 is blue green in color.

DONACIA (DONACIA) LYNNI, new species

From Lynn Creek interglacial lignite collected by Walter MacKay Draycot 1945, 8 miles northeast of Vancouver City.

Holotype LC 16; paratype LC 14. Length of holotype elytron 7.04 mm., width 2.64 mm.; ratio 2.666:1; distance between striae

0.24 to 0.26 mm.; ten striæ; color black; striæ deep and sharp cut, interspaces roundly and deeply wrinkled transversely. Paratype length of elytron 8 mm.

COMPARATIVE MEASUREMENTS OF FOSSIL DONACIA

Donacia sp.	Locality	Accession Number	Color	Length mm.	Width mm.	Ratio L:W:: —:1	Other Data
<i>ynni</i> Pierce	Lynn Cr. Vancouver, B.C.	LC 14	Black	8.00			Paratype
		LC 16	Black	7.04	2.64	2.666	Holotype
<i>longatula</i> Scudder	Fort Riv. Hadley, Mass.		Shining piceous	7.25	2.2	3.295	Type
<i>ordovæ</i> P.	Cordova B. B. C.	CB 5	Bluish purple	6.00	1.76	3.409	Holotype
<i>nnelli</i> Cockerell	Cordova B.		Green	5.00	1.50	3.333	Type
<i>ompatica</i> Scudder	Scarboro, Ontario		Metallic green	5.00	1.45	3.448	Type
<i>raycoti</i> P.	Lynn Cr.	LC 74	Blue green	4.7	1.68	2.809	Holotype
		LC 27	Black	4.40	1.60		Cast
		LC 31	Black		1.592		Paratype
		LC 15	Deep blue	4.48	1.52	2.947	Paratype
		LC 162	Deep blue	4.40	1.52	2.894	Partial pair
		LC 143	Deep blue	4.16+	1.52		
		LC 141	Deep blue		1.52		
		LC 4	Blue	4.40	1.52	2.894	
		LC 63	Black		1.52		Cast
		LC 10	Black	4.48	1.44	3.111	
		LC 197	Deep blue		1.44		
		LC 152	Deep blue		1.44		
		LC 66	Deep blue		1.44		Cast
		LC 11	Deep blue		1.44		
		LC 9	Deep blue		1.44		
		LC 93	Black		1.44		
		LC 113	Black	4.40	1.28+		
		LC 168	Black	4.24			Inside
		LC 70	Deep blue	4.16			
		LC 13	Deep blue	4.00	1.20+		
<i>irioides</i> Wickham	Sangamon R. Mahomet, Ill.	LC 28	Deep blue	3.60	1.60	2.25	Inside
			Metallic blue	3.85	1.50	2.056	
<i>iria</i> Scudder	Scarboro, Ontario		Deep blue- black	3.2+	1.4		

Thus on size and ratios the new species separate from the described species. When the other materials at hand are studied a key to the sculpture will also separate them adequately.

THE ALLOTYPE OF *THRASSIS AUGUSTSONI*

Hubbard, 1949 (Siphonaptera)

G. F. AUGUSTSON¹

During the early part of 1949 the writer was fortunate in obtaining a small series of fleas taken from Nelson Ground Squirrels by Mr. A. C. Hawbecker, Mammalogist, Fresno State College. The host animal was collected in Fresno County, California, near the town of Mendota.

At approximately the same time, Dr. C. A. Hubbard, made a similar collection further south in Kern County. The fleas in this collection were males only, a species new to science, and described by Dr. Hubbard in the Bulletin of the Southern California Academy of Sciences, Vol. XLVIII, 1949, Part 2.

Due to the effort of Mr. Hawbecker, the writer was able to obtain another series of these fleas in which a number of females were present that are herein described.

THRASSIS AUGUSTSONI Hubbard

Allotype female

HEAD: Frontal tubercle high, acuminate; preantennal region with two rows of bristles, the upper row with three bristles, the uppermost bristle the longest, middle bristle close to the uppermost, lower row of two bristles set along genital margin; eye elliptical, heavily pigmented; maxillæ sharply acuminate; labial palpi five segmented, extending slightly beyond fore-coxæ; post-antennal region with two large bristles along margin of antennal groove, ten to twelve small setæ also present along margin; row of long bristles on second segment of antennæ.

LEGS AND THORAX: Ponotal ctenidia with 19 spines; outer surface of fore-femur with many fine bristles; thin bristles on inside of mid- and hind-coxæ from base to apex. Fifth tarsal segments with five pairs of lateral plantar bristles.

ABDOMINAL SEGMENTS: Abdominal tergites with two rows of bristles; tergal teeth present on segments I to IV; three antepygidial bristles, the lower two longer than upper bristle; style short, twice as long as greatest width, with two lateral bristles; sternite X angulate, with many large bristles; sternite VII with distinct sinus, variable as in other members of genus, upper lobe

¹Manager, Madera County Mosquito Abatement District, Madera, California.

flat, smaller than lower, with four bristles in a row; spermatheca globular, the arm swollen distally.

ALLOTYPE: A female collected by A. C. Hawbecker, 11 miles east of Llanada, San Benito County, California, January 22, 1950, from *Citellus n. nelsoni*, deposited with the U. S. National Museum, Washington, D. C.

PARATYPES: Fourteen females collected as above and retained in writer's collection.

REMARKS: As Dr. Hubbard indicated (ibid) this flea is close to *Thrassis gladiolis*, difference noticeably in finger and VIII sternite in the males (misabeled as IX sternite in holotype description). Female identification can be made only on a close comparison of the spermatheca and sternite VII of both species.



PLATE 3

Thrassis augustoni Hubbard, allotype, sternite VII and spermatheca.

A NEW SPECIES OF STENOCHARIS GROSSBECK
AND TRANSFER OF THREE RELATED
SPECIES TO THE GENUS
(Lepidoptera: Geometridæ)

By HAHN W. CAPPS

Bureau of Entomology and Plant Quarantine, Agricultural Research Administration,
United States Department of Agriculture

The only species heretofore assigned to the genus *Stenocharis* has been its type, *permagnaria* Grossbeck.¹ In addition to the new species described herein, three Mexican species, *Coenocharis cornifrons* Dyar,² *C. hoplitaria* Dyar,³ and *C. rhadinaria* Dyar,⁴ which properly belong in *Stenocharis* are hereby transferred to it. The new species, *arizonensis*, is closest to *rhadinaria*.

STENOCHARIS ARIZONENSIS, new species

Male (pl. 4, fig. 3).—Antenna bipectinate. Frons strongly produced. Tongue well developed. Labial palpus with third segment short (one-half as long as second), porrect or drooping. Fore tibia unarmed. Hind tibia with two pairs of spurs; without hair pencil. Body color grayish with an intermingling of brown and fuscous. Forewing ground color grayish with three brownish uneven lines, the lines often with a zig-zag appearance, indistinct near costa, stronger posteriorly; posterior transverse line usually broader and more clearly defined than anterior and median transverse lines; a rather conspicuous brownish area bounded by veins 2 and 4. Hind wing gray-brown with the brown predominate in area between discal cell and outer margin; post medial line narrow, evenly curved, poorly defined. Under surface of fore and hind wings without conspicuous markings.

Alar expanse 35-40 mm.

Genitalia (pl. 4, figs. 1, 1a).—Uncus simple, hooklike, flattened, dilated and slightly bifid distally. Gnathos narrow with a simple, short, apical hook. Harpe, simple, unarmed, elongate. Anellus with sclerotization of lateral arm constricted near middle, effect hingelike; upper portion of arm conspicuously enlarged, toothlike in shape. Aedeagus (fig. 1a), slender, strongly attenuate distally; without cornuti.

¹Bul. Amer. Mus. Nat. Hist., 31: 400-401, 1912. Barnes and McDunnough, Check List of the Lepidoptera of Boreal America, No. 4536, 1917. McDunnough, Check List of the Lepidoptera of Canada and the United States of America (Part I, Macrolepidoptera), No. 4581, 1938.

²Proc. U. S. Natl. Mus., 47: 390, 1914.

³Proc. U. S. Natl. Mus., 42: 92, 1912.

⁴Proc. U. S. Natl. Mus., 51: 30, 1916.

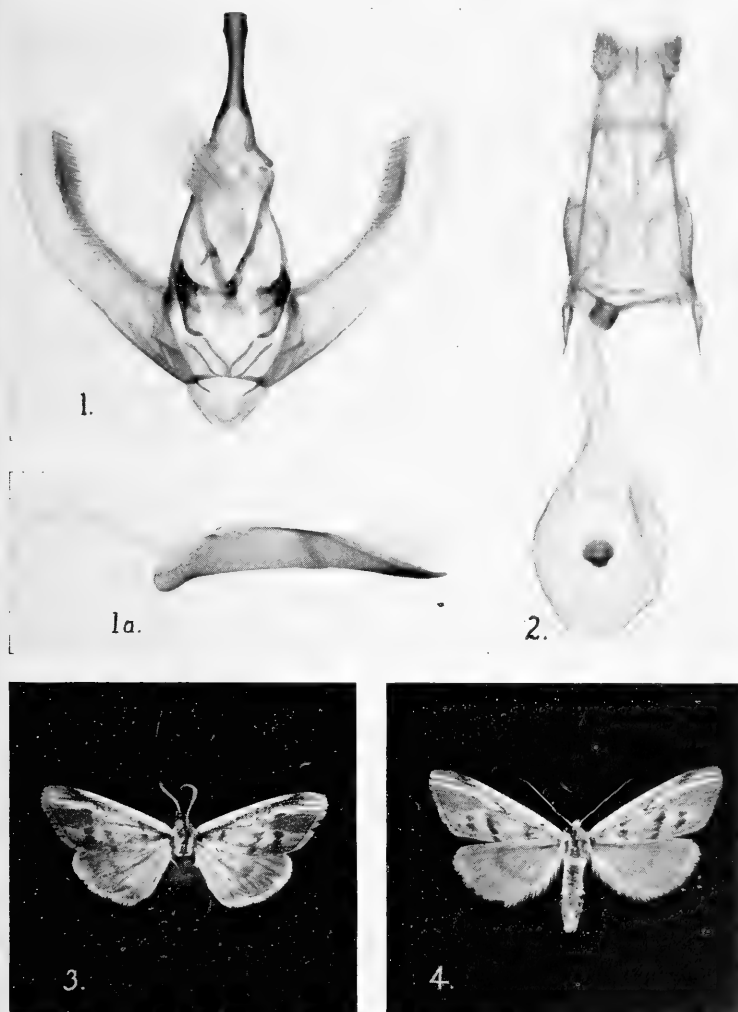


PLATE 4

EXPLANATION OF PLATE

- FIG. 1. Male genitalia with aedeagus removed, ventral view.
FIG. 1a. Aedeagus.
FIG. 2. Female genitalia, ventral view.
FIG. 3. Male adult.
FIG. 4. Female adult.

Photographs by Dr. José Oiticica Filho.

Female (pl. 4, fig. 4).—Antenna slightly serrate. Similar to male in maculation but with the colors less contrasting and coloration of hind wing more uniform.

Alar expanse 37-43 mm.

Genitalia (fig. 2) with a rather narrow sclerotized band along lower margin of genital opening; a well-defined incomplete collar-like structure slightly below genital opening; ductus seminalis from ductus bursae near base of collar; signum a small disklike plate with serrate projections (3 teeth).

Type.—In U. S. National Museum, No. 59498.

Allotype.—In Los Angeles County Museum.

Paratypes.—In Los Angeles County Museum, American Museum of Natural History, and U. S. National Museum.

Type locality.—Hereford, Arizona.

Remarks: The type series composed of five males in collection of U. S. National Museum from the Barnes Collection; one male from the American Museum of Natural History via Dr. McDunnough; and two males and two females from the Los Angeles County Museum via Lloyd M. Martin. Specific data on labels as follows: ♂ Type, Hereford, Ariz., C. R. Biederman Coll., Barnes Collection; ♀ Allotype, Madera Canyon, Santa Rita Mts., Southern Ariz., Aug. 3, 1947, collected by Dr. J. A. Comstock and Lloyd M. Martin and also two male and two female paratypes with same data except collecting dates (1 ♂ July 2, 1 ♂ Aug. 2, and 1 ♀ Aug. 7). Other paratypes as follows: 1 ♂, Ariz., Fred'k. Lemmer Collection, No. 2, Barnes Collection; 1 ♂, Paradise, Cochise Co., Ariz. (July), Barnes Collection; 1 ♂, Palmerlee, Ariz., B. Collection, 6-20-09, Barnes Collection; 1 ♂, Ariz. (Oct. 26), Barnes Collection; 1 ♂, Chiricahua Mts., No. 12, J. A. Grossbeck Collection.

NATURAL HISTORY OBSERVATIONS ON PROPHYSAON ANDERSONI (J. G. COOPER), WITH SPECIAL REFERENCE TO AMPUTATION

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Little is known of the natural history of California slugs, and especially of the genus *Prophysaon* which possesses the remarkable ability of tail amputation. Natural history work was undertaken in the hope that some plausible phenomenon might be forthcoming to show why *P. andersoni* (J. G. Cooper), the local representative of this genus, amputates its tail. Collections and field observations were made in two areas of Oakland, California; these were Redwood Park and Montclair. The natural range of *P. andersoni* is listed by Pilsbry (1948) from California to Alaska.

This study has been carried on for a period of one and one-half years, during which time fifty-three slugs were collected in the two above named areas. These two areas show a marked resemblance to one another in that a stream runs through each and the tree association is the coastal redwood, *Sequoia sempervirens* Endl., and the California bay, *Umbellularia californica* Nutt. Occasional willows are found along the stream banks, and a small stand of eucalyptus is found, in addition, in the Redwood Park area. The shrubby plants consist largely of poison oak and berry vines. Numerous lower plants also occur such as ferns, liverworts and mosses, particularly along the stream bank, as well as numerous fungi. One of the more obvious fungi was *Tricholoma terreum* Fr. which occurred in large numbers in the stream bed in Redwood Park before the rainy season set in. During the rainy season the clay soil of these areas is well saturated and very cohesive; in dry periods a thick dust forms on the surface of the soil.

The first collections were made in October, 1948, after several rains had thoroughly soaked the soil. At the time slugs were collected both under cover and in the open. The cover especially preferred by *P. andersoni* during the rainy season seems to be in such places as beneath sprung bark of the California bay and eucalyptus, under sequoia logs, brush piles and in the eucalyptus trash that accumulates under such trees. In the open slugs were taken from discarded newspapers and cardboard, and were found crawling on the trunks of eucalyptus and bay trees. After the original collection in October, trips were made periodically until

January, 1949, when the writers were not able to find slugs after thorough searches. This dearth of slugs continued until April, 1949, when field trips were discontinued.

Field trips were resumed in September, 1949, with good success, when twelve specimens were collected in Redwood Park. Other trips added more specimens without difficulty throughout October 1949, when collecting was suspended. The ground in September and October was very dry; a dusty surface being present. The main stream was not running and was devoid of water pools until the middle of October when a storm filled a few stream bed concavities with standing water. During these months no slugs were found under the bark of trees or around their bases in leaf debris piles which were thoroughly dry. Examination of the stream bed, however, revealed that individuals of *Prophysaon andersoni* had sought the last possible moisture reservoir, the moist areas on the bottom under rocks. In all cases where these slugs were taken from the stream bed they were found clinging to the clay soil and not to the rock that covered them. Sandy areas of the stream bottom were apparently avoided by this slug even though moisture and rocks were available in such areas. In the areas during the observation period it was noted that during dry periods when the stream bed lacks running water that the slug seeks its shelter. During the first rains when the stream starts to accumulate water the slugs move from the bottom of the bed to the area of the banks. With heavier and more steady rains the slugs move even farther from their summer locale, finally to return to it as moisture becomes less and less available.

Slugs collected in the field were transported to the laboratory where they were maintained in terraria. In terraria slugs fed upon lettuce, potatoes, carrots, and on three species of mushrooms, *Tricholoma terreum*, *Agaricus campestris* Fr. and *Pholiota præcox* Fr. The importance of fungi in the diet of *P. andersoni* is not known, but of the several foods offered to this slug the fungi were the most readily accepted and devoured.

Several writers have shown interest in the ability of this slug and other members of the genus *Prophysaon* to amputate the posterior region of the body. Raymond (1890) and Pilsbry and Vanatta (1898) imply that amputation may or not take place in *Prophysaon andersoni*; for example Raymond (1890) states, "In August, 1888, I collected on one occasion about a dozen examples of *Prophysaon andersoni* J. G. Cp., near the San Jose reservoir, above Lexington, Santa Clara County. While taking measurements of living specimens, before putting them in alcohol, I noticed in several a contraction about two-thirds of the length from the head. This appeared as an indented line completely encircling

the body. Upon handling the slugs to examine this phenomenon more closely, the line became deeper, and in the case of two specimens the tail dropped off, almost as readily as the ray of the so-called 'brittle' starfish." Pilsbry and Vanatta (1898) remark, "Nearly all full grown alcoholic specimens of *P. andersoni*, *foliolatum*, and *coeruleum* show a well defined impressed line around the tail, or occasionally the tail has actually been amputated." These authors further state, "Dissection shows that the body cavity does not extend beyond the point of excision, or but very little beyond; the remainder of the tail being occupied by very spongy vesicular connective tissue."

Hemphill (1890) also was interested in this phenomenon of amputation which he reported to occur spontaneously in a specimen of *P. foliolatum*. He placed a specimen showing a constriction around its tail in a box of wet moss and twenty-four hours later found it had amputated. He reported that the "... tail piece had as much vitality as the other part of the animal ...". This specimen was sent to Binney, who (1892) reported that when he received the slug that the front piece was in good health, but that the "... tail piece was in an advanced state of decomposition."

Ingram (1948) reported no cases of amputation in *Prophysaon andersoni* after what seems to have been severe and unnatural treatment. He starved his slugs, dropped them into 3% formaldehyde, and his "... slugs were pinched from time to time with forceps, shaken in a closed container, dropped on a wooden floor from a height of five feet and pricked with a scalpel without throwing off the posterior body region."

Pilsbry (1948) in a summarizing paragraph makes the following remarks: "Everyone observing living prophysaons has noticed their faculty for amputating the tail. Many specimens show an impression extending obliquely around the tail ... During examination the furrow deepens, and the tail may drop off in the hand. More frequently it comes off in the drowning jar. On examination it appears that the visceral mass does not extend beyond the point of excision, the body cavity beyond being occupied by a spongy, vesicular mass of connective tissue. Is excision of the tail followed by regeneration? Probably so, but we do not know. In a considerable number, I have seen no definite evidence of new outgrowth. It is a question for those who can observe them in the field, or better, keep them in captivity."

It is quite clear then, that beyond recognizing that *Prophysaon andersoni* (J. G. Cooper) and other members of the genus can amputate their tails, little is known. No natural stimulus to amputation is suggested in the literature, and it appears in some cases that amputation either cannot be accomplished at all or only with

difficulty. It is to this problem that the authors devote the rest of this report.

Merely handling did not induce amputation in *P. andersoni* in the experience of the writers. Therefore it was decided to try running a dissecting needle completely through the tail at a point behind the amputation line in an attempt to cause amputation. This was done and to the writer's satisfaction amputation followed. After the needle had been run through the tail of the slug, the slug was suspended on the needle and the time from penetration to amputation was recorded with a stop watch. Of the slugs tested 5 amputated on the first trial. The times recorded were 7, 14, 14, 15 and 29 seconds, or an average of 15.8 seconds.

The slugs tested did not amputate in every case on a single thrust and a second piercing was necessary to cause amputation. The table below presents this data.

Slug Number	Time suspended without amputation	Time for amputation after second stimulus
1.	3 minutes	30 seconds
2.	5 minutes	40 seconds
3.	2 minutes	22 seconds
4.	6 minutes	10 seconds
5.	4 minutes	23 seconds

The average time required for amputation by these five slugs on the second stimulus was 25 seconds.

With one slug a third trial was necessary, the first two having failed to cause amputation. This slug was suspended 3 minutes on each of the two unsuccessful trials, and 20 seconds was required for amputation to take place on the third trial. Still another slug required a total of 5 stimuli before amputation was induced. The four unsuccessful trials lasted 2, 3, 4 and 4 minutes, while 20 seconds were taken on the fifth thrust to complete amputation.

To see if amputation could be induced consistently with a single stimulus, a more severe stimulus was used. This consisted of cutting through the tail about halfway between the amputation line and the tip with a scalpel. Seven slugs were treated in this manner with the following results: two slugs in a semicontracted condition were cut and required 29 and 47 seconds respectively to amputate; in four other cases moving slugs were cut and these required 5, 12, 19 and 34 seconds to amputate. The first of these four was pinned to the table by the scalpel, and it may have been that the unusually short amputation time (5 seconds) was due to leverage applied by this slug against the pinned tail. With the seventh slug the tail was cut cleanly away, but amputation had not occurred after 25 minutes. The results of this group of seven trials show that the more severe stimulus gives a greater number

of amputations with a single trial (6 out of 7) than the stimulus with the needle where only 5 out of 12 amputated on a single thrust.

In considering all of the data above it appears that there are different abilities to amputate. In some cases a single thrust through the tail with a needle is sufficient to cause amputation, while in some two thrusts are required, or it may take as many as five trials to actually cause autotomy. . When a stronger stimulus is applied, such as actually cutting off part of the tail, autotomy is almost sure to follow with a single stimulus, although the time required varies from individual to individual. This suggests that a certain threshold of stimulation must be reached before amputation is possible, and that this threshold varies from specimen to specimen. Certainly there is an obvious difference from slug to slug which may correlate with the fact that some authors have reported ease of amputation (Raymond, 1890; Hemphill, 1890) and others (Ingram, 1948) have been unable to induce amputation even with severe handling.

In losing the tail the following details were readily observed. Constriction begins rapidly at the sides of the body at the amputation line. This constriction runs up over the dorsum and is by then also strongly marked on the sole. The sole is the last area to actually amputate, the amputation of the body occurring first and the sole following immediately. In amputating, the constriction gets deeper and deeper until it suddenly has cut the body into two portions.

Serial sections were prepared of the posterior half of four *Prophysaon andersoni* in an attempt to discover the mechanism of amputation; both cross and longitudinal sections were prepared. At the area where amputation occurs, as judged by the position of the amputation line, some special structures were found which can only be explained as part of the amputation mechanism. At the site of the amputation line and extending inward to the body cavity there occurs a sheet of vacuolated cells which completely surround the body of the slug. Figure 1 illustrates the appearance of the amputation line on a slug, while figure 2 is a diagram constructed from longitudinal sections showing the vacuolated cells. It was found that immediately anterior and posterior to this sheet of vacuolated cells there is a region which apparently is devoid of longitudinal muscle fibers. This region appears to consist of only circular muscle cells; the portion anterior to the vacuolated cells is about twice as thick as the portion posterior to these cells. Another structure discovered in the longitudinal sections was a muscular sac, which is attached to the body wall at a number of points, and which bounds the viscera posteriorly. Figure 2 shows that this sac takes its origin

largely anterior to the sheet of vacuolated cells, but that some of its fibers are attached posterior to that point.

The role played in the process of amputation by the various structures mentioned above seems to be as follows: The sheet of vacuolated cells extending round the body of the slug acts as an abscission layer. The circular muscle cells immediately anterior and posterior to the vacuolated sheet may function in the constriction of body which leads to tail amputation. The circular muscle cells anterior to the abscission layer, by their sphincter-like action, also appear to be those that keep the posterior region of the body tightly closed after amputation (figure 5). The muscular sac which is found enclosing the viscera may have a dual function. When the slug is fully extended some viscera extend posteriorly beyond the amputation line: if amputation were to occur with the slug in this condition it might well cut off some of its viscera as well as lose body fluids. The muscular sac appears to definitely function as a device for pulling in the viscera if they are left outside the body cavity at the time of amputation. In one instance, a mass of liver tissue about 3 mm. in diameter was actually left outside the body at the time of amputation; this mass was subsequently slowly withdrawn into the body, presumably by the action of the muscular sac.

Following amputation it was of interest to discover that the amputated tail was able to crawl about freely, and at a speed which was somewhat slower than that of an entire slug. If an amputated tail was placed upon a smooth surface, such as the table top, it proceeded to crawl for as far as six inches before it toppled to its side. The path taken by the tail piece was always erratic. Once the tail had fallen off its locomotor surface it could not right itself. If a tail, which had fallen over, was righted it again crawled as before. This unusual vitality of the amputated tail was noted by Hemphill (1890).

The tail piece showed no ability of regeneration. In several cases where the amputated tails were placed in terraria they were found in a decaying condition within 24 hours. Figure 3 shows a freshly amputated tail in lateral view. The face of the amputated piece corresponds to the location of the sheet of vacuolated cells found in the longitudinal sections and also to the amputation line visible on the intact slug. Figure 4 shows an anterior view of an amputated tail piece. It should be noted that the wound has not closed here as it has on the body (figure 5). At the time of amputation the posterior area of the body wall of the slug closes tightly at the point of amputation and becomes highly puckered. After amputation the foot of the body contracts to form a notch at its termination as is shown in figure 6. At the time of amputation small quantities of mucous are secreted from the amputated area.

Pilsbry and Vanatta (1898) have reported that the body cavity did not extend beyond the point of amputation or but little beyond. We, however, have found that the body cavity always extends beyond the point of amputation, providing that the area posterior to the muscular sac described above can be called a body cavity. This space is indicated by the depression seen in the face of the amputated tail (figure 4) and by the space posterior to the muscular sac in figure 2. The amputated tail, as reported by others, consists to a great extent of a spongy vesicular connective tissue.

Six slugs which had amputated their tails were placed in a terrarium for further study. Fourteen days after amputation the slugs were carefully examined; each slug still showed a definite puckering at the point of amputation. The puckering was less pronounced than it had been at the time of amputation, but there was no sign of the growth of a new tail. Gentle probing of the puckered area indicated that healing had taken place to the extent that the body cavity was well sealed. The posterior of the foot was still indented. After 30 days 2 of the slugs died; the 4 remaining slugs still showed a small puckered area, while 3 showed a small indentation at the termination of the foot. The fourth slug now had a very small new tail. No sign of a new amputation line was visible. At the end of 52 days only 3 slugs remained alive. Each of these had lost all signs of the puckered area which had once marked the point of amputation, and each possessed a small new tail. These tails were not demarked from the body by a visible amputation line. They were readily distinguishable, however, as new tissue by the fact that the soles of the new tails were a dark gray rather than the characteristic white of a slug that had not undergone tail amputation. The new tissue of the tails was approximately 4 mm. long and tapered very rapidly to a point. The last of the three surviving slugs died on the 74th day; up to this time a new amputation line was not observed.

A second lot of six slugs that had amputated their tails were placed in a terrarium in the hope that they could be kept alive longer than the above lot, and also be induced to grow not only a new tail but an amputation line as well. At the end of 38 days each of these slugs lost the puckered area and the notch at the end of the foot. One slug died on the 51st day and a second on the 60th. At the end of 72 days each of the four remaining slugs had a new tail which was 5 mm. long. Again, the regenerated tails were a dark gray on the sole rather than the white of the rest of the foot. Two slugs died on the 79th day and another on the 84th. At 97 days the last surviving slug was examined and was found to have a well developed tail and a clearly developed amputation line as well. The appearance of this slug at that time

is shown in figure 7. The tail from the amputation line to the tip was 7 mm. long. It was observed that the gentle slope from the amputation line to the tip of the tail which characterizes slugs that have not amputated tails was missing. Instead the new tail was rather abruptly joined to the body piece. The new amputation line occupied a much more vertical position than it does in normal slugs where it slopes obliquely forward up the body. Thus as suggested by Pilsbry (1948), *Prophysaon andersoni* can regenerate a new tail. This slug died on the 107th day before an attempt was made to see if it could amputate a second tail and again regenerate another.

Of the 53 *Prophysaon andersoni* collected in this study, three, at the time of collection, had already lost their tails. In each slug amputation had occurred long enough previous to their collection so that the amputated area was well healed. In two of the slugs a new tail about 3 mm. long was present, while in the third the tail was 8 mm. long and a new amputation line was present. A needle was run through the tail of the slug with the 8 mm. long tail and amputation followed in 17 seconds. Thus it is indicated that *Prophysaon andersoni* may regenerate a new tail and an amputating mechanism as well.

From the condition of the three slugs mentioned above it appears that amputation occurs in nature in *Prophysaon andersoni*, although its cause or utility to the slug is unknown. In seeking to find a cause for tail amputation in this slug in the field we decided to investigate the relationships between the slug and some of its associates. The animals that were found in close association with *P. andersoni* that might possibly cause tail amputation were especially noted with the thought in mind that aggressive predators might seize the slug by the tail; thus, amputation might function in leaving the tail for the predator while the slug crawled away to survive. In September and October of 1949 the following vertebrates were noted in close association with *P. andersoni*: salamanders, *Triturus torosus* (Rathke), *Batrachocephalus attenuatus attenuatus* (Escholtz), *Aneides lugubris lugubris* (Hallowell), *Ensatina escholtzii* (Gray); the frog, *Hyla regilla* Baird; and the garter snake, *Thamnophis ordinoides atratus* (Kennicott). Two predatory invertebrates, the carnivorous snail *Haplotrema minimum* (Ancey) and the beetle *Scaphinotus* sp. were also closely associated with *Prophysaon*. Other mollusks that were found in slug areas that are not typically predatory were the giant western slug, *Ariolimax columbianus* (Gould) and a large native land snail, *Helminthoglypta arrosa holderiana* (Cooper). The writers sought to determine if a food relationship exists between certain of the above animals and *P. andersoni* in terraria.

Slugs were placed in terraria with *Triturus torosus*, and in no

case did the salamanders accept the slugs as food. The slugs were kept with this species of salamander for a two-week period.

When garter snakes, *Thamnophis ordinoides atratus*, were placed with *Prophysaon* they showed almost immediate interest in the slugs, and each ate a slug, swallowing it tail first. In one case the snake was killed and the slug removed about ten minutes after it had been swallowed. The slug was found in the snake's stomach where it was alive and writhing actively. This slug had not amputated its tail, nor did it subsequently. The slug recovered completely and was later used in another experiment. A second snake that had swallowed a slug was opened at the end of 17 hours, and the slug removed. This slug was dead, but again the tail had not been amputated.

The carnivorous snail, *Haplotrema minimum*, found in considerable numbers in the areas inhabited by *Prophysaon*, was paired in single pint jar terraria with *Prophysaon*. As controls single specimens of *Prophysaon* were isolated in similar jars. Five slugs amputated their tails when confined as above with *Haplotrema*, while the control slugs did not. In two instances amputation occurred within 24 hours of the initiation of the experiment, but there was no sign of injury to either the tail or body of the slug. In a third case amputation did not occur until the third day at which time the slug was found in an amputated condition, and no sign was found of the tail. In a fourth case amputation occurred in 4½ hours, and not only had the tail been eaten, but the head as well had been devoured so that the viscera were exposed. In the fifth case the tail was amputated and eaten within 24 hours; 24 hours later the entire slug had been eaten.

It was observed that when *Haplotrema* and *Prophysaon* were placed together, that *Haplotrema* attacked the *Prophysaon* by biting at them. This biting always stimulated the slug to move away from the snail. It was noted that a contracted slug would begin to move with the first bite, whereas pinching a contracted slug with forceps seldom would cause it to move. When *Haplotrema* struck at *Prophysaon*, the slug exuded a light creamy mucous, but this did not seem to cause the snail to cease striking. The extent to which *Haplotrema* feeds on *Prophysaon* in the field is not known, but in the laboratory this snail can cause amputation in *Prophysaon*.

A similar situation seems to exist between *P. andersoni* and the beetle, *Scaphinotus* sp., as with *Haplotrema* and the slug. Two slugs were isolated with separate beetles, and in each case amputated their tails. The amputated tails were eaten by the beetles. *Scaphinotus* did not kill the slugs although they were kept together for six days.

Exactly how amputation functions in *Prophysaon* is not known. We can speculate that this ability is an escape mechanism, and as such has been of some selective advantage to this particular group of slugs. The writers have shown above that amputation occurs in nature (3 out of 53 specimens), and also that certain natural predators can induce amputation in the laboratory. It appears that the ability to amputate would be of value to *Prophysaon* when it is attacked by relatively slow moving predators such as *Haplotrema* in that the amputated tail might satiate the appetite of the predator and at times allows the slug to crawl away unnoticed.

Noting the close relationship of this slug to moisture, we asked if this slug could not conceivably use its rather spongy tail as a moisture reservoir to hold it over dry periods, perhaps amputating its tail after all moisture had been withdrawn. To test this idea a slug was placed in a desiccating chamber using anhydrous calcium chloride as a desiccating agent. In the first test 50 grams of CaCl were used, and at the end of 24 hours the slug was completely dried out but had not amputated. A second test was made in which only 5 grams of CaCl were used, but again at the end of 24 hours the slug was dead and had not amputated the tail. This time the slug was leathery, rather than hard and dry at the end of the first experiment. It is not felt that these were conclusive experiments, and further work on desiccation might reveal a desiccation-amputation relationship.

SUMMARY

1. In the Oakland area the slug *Prophysaon andersoni* is commonly found in redwood-bay associations
2. This slug seems highly dependent upon water in that it is found only in damp places. These damp places may be under the bark of living or dead trees, in moist leaf piles, under rocks in damp stream beds, or out in the open if the ground is damp.
3. Several mushrooms were readily fed upon by this slug.
4. Amputation can be induced artificially in *P. andersoni* by thrusting a needle through its tail or by severing a part of the tail.
5. *P. andersoni* possesses several special structures which are interpreted as functional parts of the amputation mechanism. These consist of a sheet of vacuolated cells surrounding the body at the amputation line which act as an abscission layer. Anterior and posterior to the abscission layer there is an area of circular muscle cells that apparently function in body constriction which results in amputation. The anterior set of circular muscle cells also appear to function in keeping the

- posterior end of the body tightly closed after amputation. A sac-like muscular sheet that encloses the viscera posteriorly and divides the body cavity into an anterior, visceral cavity, and a posterior, caudal cavity. This muscular sac appears to function in pulling the viscera into the visceral cavity at the time of amputation.
6. A question of Pilsbry (1948), "Is excision of the tail followed by regeneration?", is definitely answered. After amputation *P. andersoni* can regenerate a new tail.
 7. Several potential predators of *P. andersoni* were found living in close association with it. Of the ones tested, only the snake, *Thamnophis ordinoides atratus*, the snail, *Haplotrema minimum*, and the beetle *Scaphinotus* sp. accepted this slug as food in the laboratory. Of these predators, only the snail and beetle caused *P. andersoni* to amputate its tail in the laboratory.
 8. Amputation may be of some advantage to *P. andersoni* in that if this slug is attacked by a rather slow moving predator such as the snail the slug can amputate its tail, leaving the tail to satiate the appetite of its foe while it crawls away.

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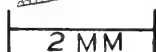
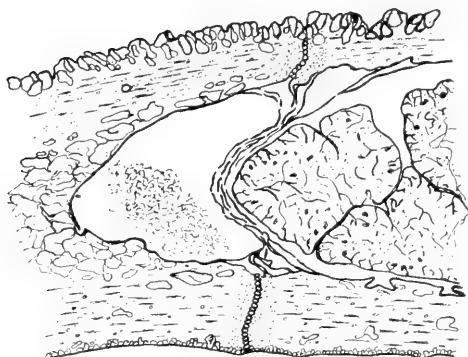
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PILSBRY, H. A.

1948. Land mollusca of North America (North of Mexico). Acad. Nat. Sci. Phila., Monograph 3, vol. 2:2, p. 680.



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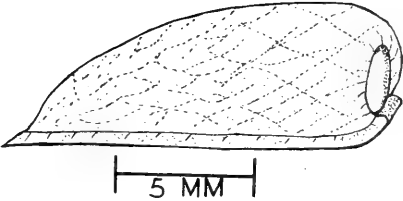
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PLATE 5

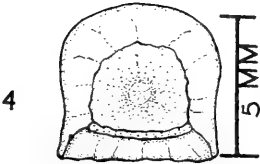
EXPLANATION OF FIGURES

FIG. 1. Lateral view of *Prophysaon andersoni* showing amputation line as it appears externally.

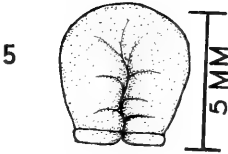
FIG. 2. Longitudinal section through the posterior part of the body to show the vacuolated cells of the abscission layer. Liver mass section is at right, then muscle sheath that caps the viscera posteriorly, then the cavity of the tail to the left. On either side of the vacuolated cells smooth muscle cells are indicated by relatively dense stippling.



3



4



5

PLATE 6

FIG. 3. Lateral view of an amputated tail, showing to the right the cavity of the tail and the shelf ventral to it.

FIG. 4. Anterior view of an amputated tail looking into the cavity.

FIG. 5. Posterior view of a slug's body after the tail has been amputated showing its puckered appearance.

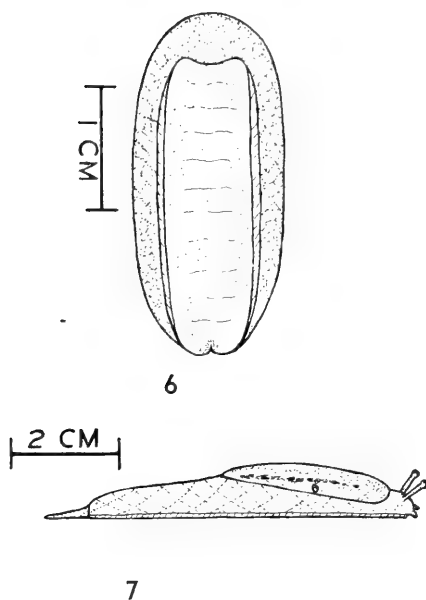


PLATE 7

FIG. 6. Diagram in ventral view of *Prophysaon* after amputation showing notch in foot below puckered area.

FIG. 7. Lateral view of a *Prophysaon andersoni* that has regenerated a new tail and a new amputation line.

A REMARKABLE NEW SPECIES OF MARINE ISOPOD,
ERICHSONELLA CRENULATA N. SP., FROM
NEWPORT BAY, CALIFORNIA*

ROBERT JAMES MENZIES

The collections of the Allan Hancock Foundation have recently been enriched by three specimens of an idotheid isopod, the gift of Mr. J. Laurens Barnard, who collected them from the marine plant *Zostera*, at Newport Bay, Orange County, California. The specimens appear to represent the first record of the genus *Erichsonella* from the Pacific Coast of North America. It is true that Boone (1923, pp. 154-155) described *Erichsonella pseudoculata* from Laguna Beach, California; however, it seems evident from the description that her species does not belong in the genus. The following species then apparently represents the only known species belonging to *Erichsonella* from the North American Pacific Coast.

ERICHSONELLA CRENULATA new species

Plates 8 to 10

Holotype. Male, length 23.0 mm., width at widest part of second peræon somite 3.0 mm. A.H.F. No. 492.

Allotype. Ovigerous female; length 17.0 mm., width 3.0 mm. A.H.F. No. 492a.

Figured paratype. Male; length 20.0 mm., width 2.2 mm. A. H. F. No. 492b.

Diagnosis. First frontal lamina (projecting lamina between first antennæ and below frontal margin) bifid; second frontal lamina widely concave at distal margin. Dorsum of cephalon with a conical, apically tri-tuberculate elevation. Eyes subovate. Lateral margins of peræon projecting at epimeral areas giving body a crenulate appearance. Pleotelson widest near distal end; posterolateral angles each with a small depression; distal medial projection of pleotelson evenly rounded.

Character of body. Entire animal very elongate, about 8 times as long as wide. Color in alcohol a light brownish green.

Cephalon. Median frontal margin almost straight; antero-lateral areas projecting distally farther than medial frontal

*Contribution from The Allan Hancock Foundation.

margin. First frontal lamina bifid, extending forward about one half the length of the first article of the first antenna. Second frontal lamina (the projection ventral to the first frontal lamina) does not extend forward beyond the first frontal lamina. Third frontal lamina not visible in dorsal view. Eyes subovate, located on lateral margin and slightly swollen laterally. Dorsum of cephalon with a conical, apically trituberculate elevation.

Peræon. Somites of peræon in general smooth, lacking swollen supralateral projections; lateral margins extended laterally at epimeral areas. Epimeral plates visible in dorsal view on somites 2-7 inclusive. First somite shortest (as measured on mid-line), fourth somite longest, about two and three-fourths times the length of first and one and one-half times the length of seventh somite. An elevated tubercle is conspicuous in the mid-dorsal line at the posterior margin of somites 1-5 inclusive.

Pleon. Composed of a single somite with possibly two very indistinct lateral incisions on either side indicating somite separation in the proximal one third of the pleon. Postero-lateral area flaring, conspicuously wider than anterolateral area. Postero-lateral angles each with a small depression; distal margin of pleotelson projecting, evenly rounded. Distal apex of uropod pointed, a single ciliated seta present on inner surface at disto-medial joint of first article.

First antenna. Composed of four segments; first and third segments subequal in length, third one and one-half times the length of second, fourth segment slightly longer than second and bearing the usual filamentous setæ on its medial margin.

Second antenna. Exceeds one half the body length. Peduncle composed of five segments; first segment very short, second and third segments subequal in length, fourth segment the longest, two times the length of third, fifth segment about two thirds the length of fourth. Flagellum composed of a single clavate segment which exceeds the fourth peduncular segment in length.

Maxilliped. Palp with four articles; only one coupling hook present on each endognath.

First pair of maxillæ. Composed of two lobes; apex of outer lobe with 14 setæ, that of inner lobe with 3 stout ciliated setæ and two smaller simple setæ.

Second pair of maxillæ. Composed of two lappets; outer lappet bilobed, apex of each lobe with 7 denticulate setæ; inner lappet apex with 14 setæ.

Mandible. Left mandible incisor with 4 teeth, lacina with 3 teeth, setal row with about 11 setæ, molar process tubular, toothed

on outer edge, with over 10 spinulate setæ in setal mass. Right mandible incisor with 4 teeth, lacinoid seta with 2 teeth (outer edge), setal row with 10 setæ, molar process with fewer but larger teeth than left, over 17 spinulate setæ in setal mass of molar process.

Penis. Composed of a medially cleft plate appearing as two separate pieces. Pieces distinctly fused at base.

Pleopods. Exopod of first pleopod margined with plumose setæ, endopod with plumose setæ on lateral margin and apex. Exopod of second pleopod with plumose setæ on lateral margin and apex, endopod with plumose setæ at apex only: male stylus exceeds distal extent of exopod but does not extend beyond the plumose setæ of exopod. Third, fourth, and fifth pleopods with both branches fleshy, lacking plumose setæ.

First peræopod. In general lacks heavy, stout setæ. Carpus with one stout seta on inferior margin. Dactyl bi-unguiculate.

Seventh peræopod. Lacks stout setæ. Dactyl bi-unguiculate.

Sexual dimorphism. Ovigerous female specimen considerably widened laterally at the peræon somites concerned with marsupium development.

Type locality. Upper Newport Bay, Orange County, California. Clinging to the blades of the marine plant *Zostera*. November 20, 1949. Collector Mr. J. Laurens Barnard.

Remarks. The proposed new species differs from *Erichsonella attenuata* (Harger) (Richardson, 1905, p. 400-401), which of the known American species it most closely resembles, in having the dorsum of the cephalon provided with a conical elevation, a pleotelson conspicuously widened distally, and a bifid first frontal lamina. In *E. attenuata* the cephalic area lacks a conspicuous elevation, the pleotelson is distally scarcely wider than the proximal part, and the first frontal lamina is simple and acuminate.

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- COONE, P. L., 1923. New Marine tanaid and isopod Crustacea from California. Proc. Biol. Soc. Washington, vol. 36, pp. 147-156.
- RICHARDSON, H., 1905. A monograph on the isopods of north America. Bull. U. S. Nat. Mus., No. 54, 727 pp.

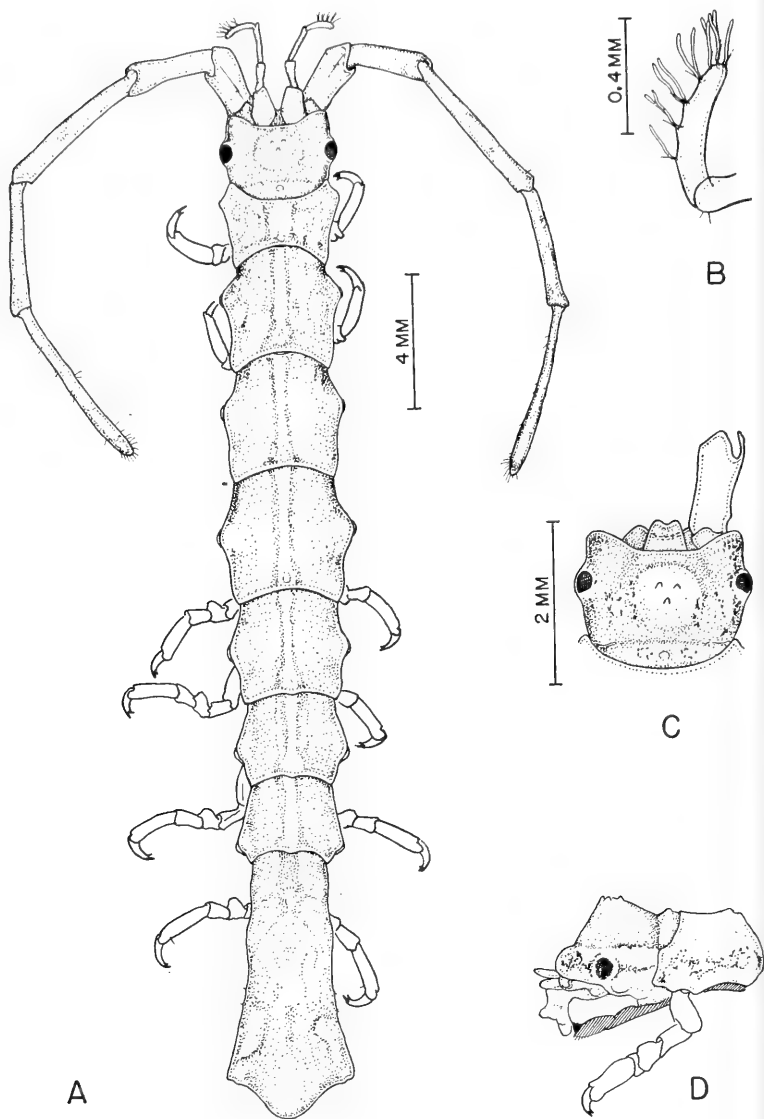


PLATE 8

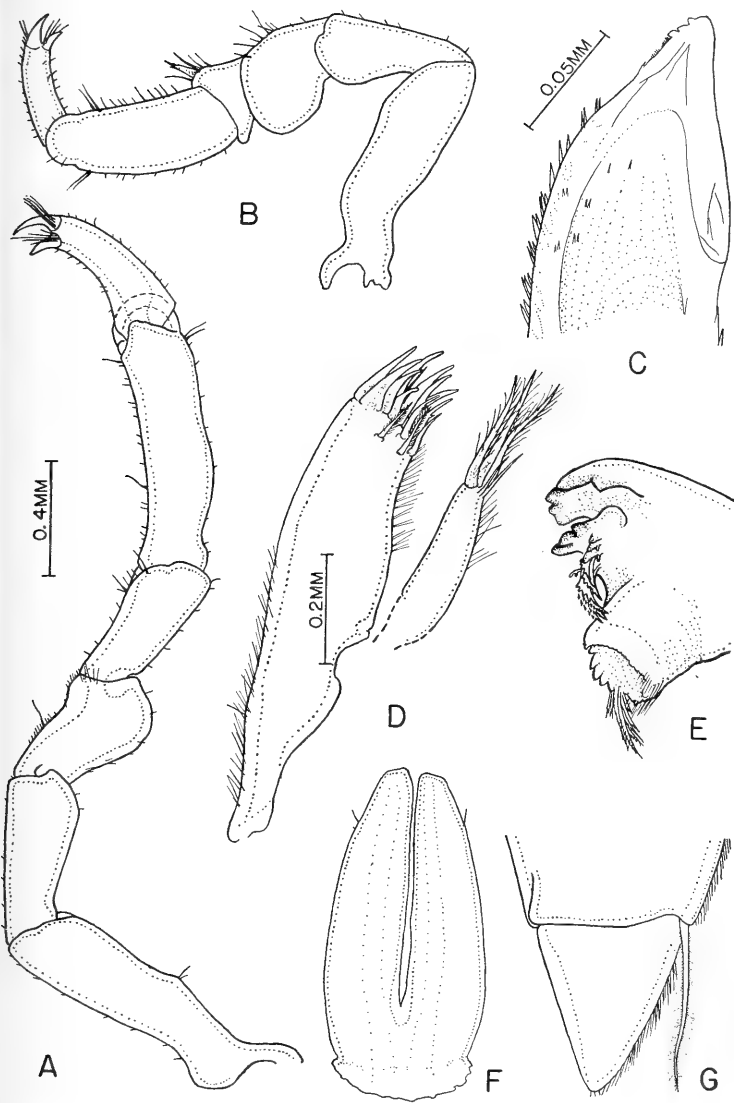


PLATE 9

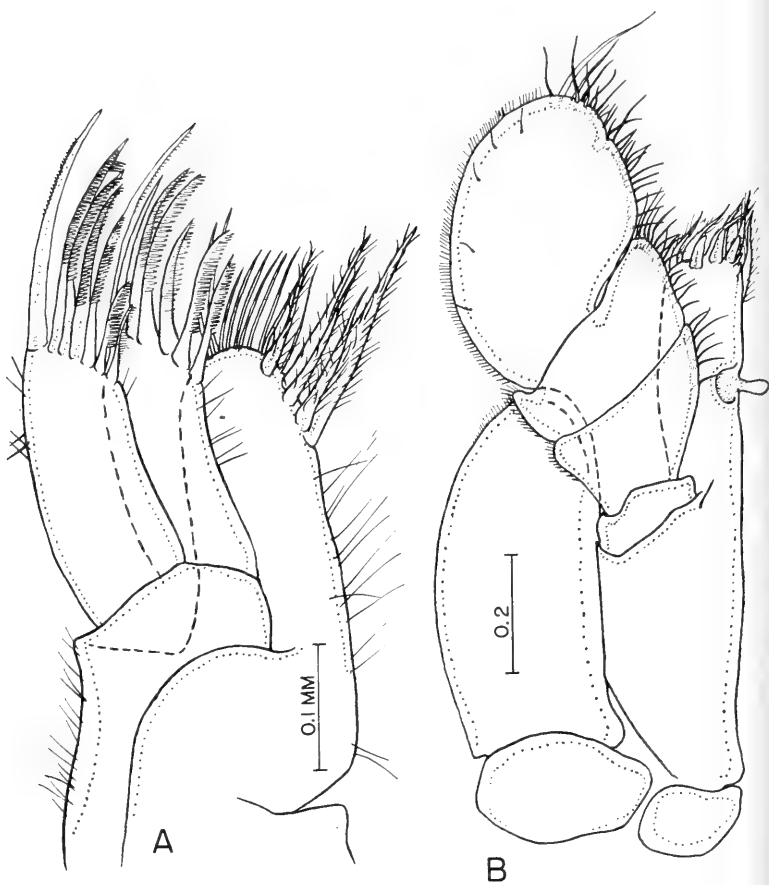


PLATE 10

PLATE 8

Explanation of Figures

ERICHSONELLA CRENULATA n. sp.

(Paratype, Male)

- A. Entire animal, dorsal view.
- B. Terminal article of first antenna.
- C. Cephalon, dorsal view.
- D. Cephalon, lateral view.

Magnification: C and D with scale same as for C; others as indicated.

PLATE 9

Explanation of Figures

ERICHSONELLA CRENULATA n. sp.

(Paratype, Male)

- A. Seventh peræopod.
- B. First peræopod.
- C. Tip of stylus of second pleopod.
- D. First maxilla.
- E. Left mandible, terminal portion.
- F. Penis.
- G. Tip of uropod, inner surface.

Magnification: A, B, G, scale same as for A; D, E, F, scale same as for D; C as indicated.

PLATE 10

Explanation of Figures

ERICHSONELLA CRENULATA n. sp.

(Paratype, Male)

- A. Second maxilla.
- B. Maxilliped.

Magnification: As indicated by scale.

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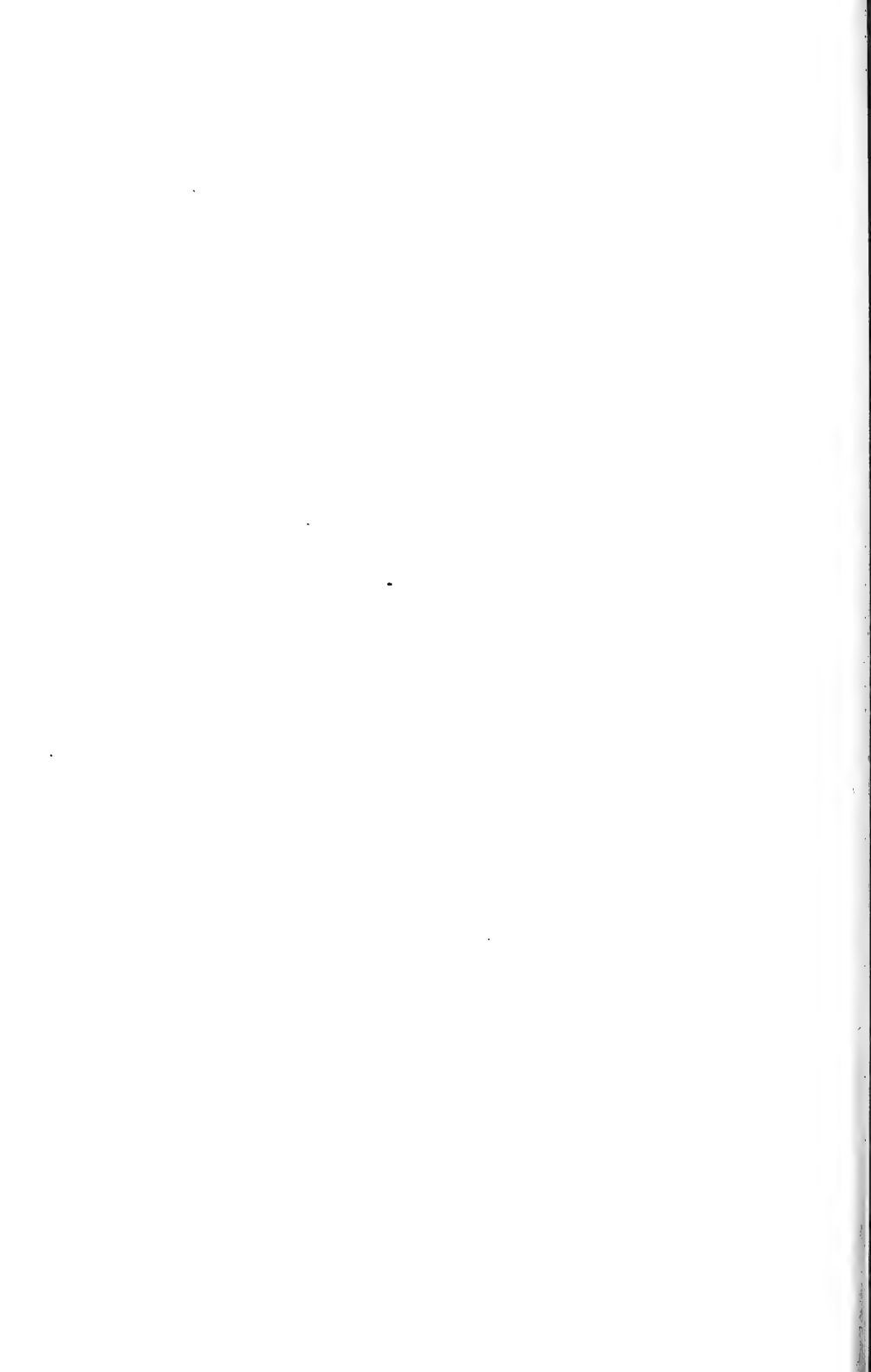
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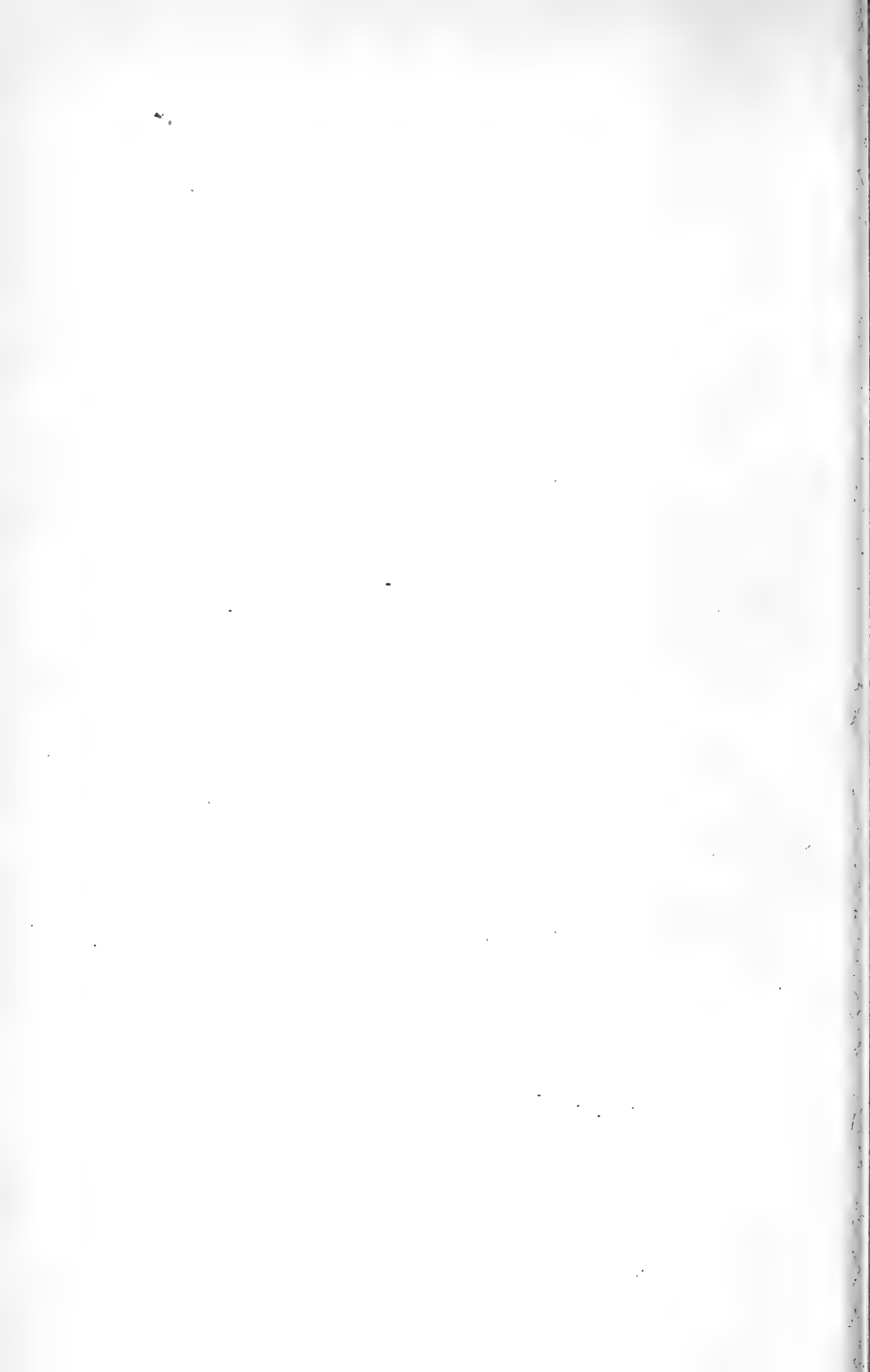
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THE EAR OF SALAMANDERS

By WILLIAM A. HILTON

Department of Zoology, Pomona College

In the adult the auditory capsule is completely enclosed by the primary skeleton which becomes almost entirely bone, although there are some differences in different groups as well as in different ages and sizes. On the dorsal surface of the skull there may be convex ridges marking the position of the semi-circular canals of the internal ear although this is far from being true of all species, especially those where the skull is particularly heavy with the development of thick bony ridges. The ventral and anterior surfaces of the capsules are usually smoother. On the postero-lateral surface, directed somewhat ventrally is a large circular to ovoid opening in the capsule, the *fenestra vestibuli*, but the position and form of this differs greatly in different groups. The margin of this opening is surrounded by membrane or cartilage and the operculum or columella or both, often of bone, sometimes cartilage, fits into this opening. The lateral wall of the capsule is attached to the suspensorium by as many as three parts. The medial wall of the bony capsule, between it and the cranium has a number of foramina:

F. PERILYMPHATICUM, for the passage of the perilymphatic duct to the cranial cavity. It is quite large and more caudal than the next.

FORAMINA ACUSTICA, for the passage of branches of the auditory nerve. There may be three openings but in some cases one or more are so sunken as to give the appearance of one or two. In the interior of the bony part of the ear of *Triturus* examined there were two openings, each in a little elevated area near the floor of the capsule.

FORAMEN ENDOLYMPHATICUM, for the endolymphatic duct, from the capsule to the cranium. This is dorsal to the auditory nerve openings and much smaller than the others mentioned.

F. POST-OTICUM, is not concerned with the ear although its opening is on the inner caudal end of the otic-exoccipital bone. It is for the passage of the 9th and 10th cranial nerves.

The otic capsules in the otic-exoccipital bone are well joined with the cranium, but with remains of the parachordal plate in some at least. At the capsule region ventrally, the two sides may be joined by the *posterior hypochordal cartilagenous commissure* and at the anterior end by a narrow cartilagenous bar, the *crista retrosellaris*.

In this way forming a *posterior fenestra basicranialis* and in front a larger *anterior fenestra basicranialis*, both covered by the basisphenoid bone and parts of others.

Dorsally the capsules are joined by the narrow *tectum synoticum* cartilage. A ring in the occipital region often remains largely cartilage, but the deeper parts of the condyles become bone and unite with the ear capsules.

The caudal face of the otic-exoccipital region shows the condyles with their articular surfaces cartilage, sometimes a part of the opercular-columella region, the foramen magnum and two pairs of smaller foramina; the outer opening of the f. post-oticum, between the condyle and opercular-columella opening and the f. faciale; the former for the 9th and 10th cranial nerves and the latter for the 7th cranial.

In most adults the ear is inclosed in the otic-exoccipital bone on each side, but in some adults, such as *Necturus*, the otic region has a rather large central cartilagenous capsule with separate bony elements as follows:

On each side a *pro-otic*, at the cephalic lateral region, an *opisthotic* at the caudo-lateral margin of the capsule and the *exoccipital* at the median caudal margin.

Internally the pro-otic contains the anterior portion of the membranous labyrinth, the canal for the anterior vertical semicircular canal with its ampulla and the anterior portion of the horizontal semicircular canal. The opisthotic has two bony canals in the dorsal wall for horizontal and vertical semicircular canals with ampullæ; the membranous vestibule contains the large otolith.

Within the ear capsule the anterior septum circulare is often a bony pillar and shelf, partly joining the roof to the mesial wall of the capsule. Other septa related to the canals are not so well developed. In viewing the bony cavity when much of the dorsal wall has been removed the following features present themselves:

A strong bridge of bone from the mesial wall to the dorsal roof. At the outer end of this last at the bottom of the capsule and toward the outside, a little of the large opercular opening may be seen. Ventral to the inner end of the bridge a tube-like elevation of bone open at each end. These two foramina were all that could be seen of the passages for the auditory nerve although three openings were seen within the cranium. This was determined by running very fine hairs through the foramina from one side to the other. A shallow shelf of bone on the cephalic and on the outer margins of the capsule a little below the dorsal surface, in which semicircular canals rest. A mound in the caudal wall inside, representing a partial support for the posterior canal. In the floor of the capsule in addition to the olfactory nerve foramina is the more caudal opening for the ductus perilymphaticus. The smaller opening for the endolymphatic duct is more dorsally placed, near the mesial shelf. On the outer side

there is a foramen from the caudal part of the outer shelf to the more ventral space below and not far from the opercular foramen.

Upon opening the ear cavity from below and viewing the interior from the other direction or toward the dorsal wall the following may be seen:

In the middle of the mesial side and toward the dorsal surface is the broad bony bridge from the mesial to the dorsal wall. At the caudal end a sharp projection may indicate something of a caudal shelf. Laterally a thin bony shelf appears like a tube with a foramen through its caudal border. In addition to this last in a solid chore where the mesial bridge joins the dorso-lateral well is a small deep foramen of unknown function. It may be for the passage of a blood vessel.

According to Harrison's interpretation, 1902, the perilymph is restricted to a definite region and the remaining space between labyrinth and capsule is occupied by perilymphatic tissue which becomes especially dense about the labyrinth.

The largest space containing the perilymph is the *spatum sacculare*, a large sac lateral to the sacculus and largely ventral to the horizontal canal, filling the whole lateral half of the capsule, in close relation to the membrane which closes the fenestra vestibulæ and operculum. The wall separating this perilymphatic space from the internal labyrinth at the sacculus is very thin. Leading off from the saccular sac of the perilymph is the *ductus perilymphaticus*, a rather wide tube almost as great in diameter as one of the semicircular canals. It passes toward the middle line, mesial to the posterior canal and the sinus posterior of the utriculus to emerge on the median side of the labyrinth, dorsal to the lagena and pars basilaris and ventral to the pars neglecta of the endolymphatic structures. It then turns ventrally and passes to the cranial cavity through the *apertura ductus perilymphaticus* in the median ventral wall of the capsule. According to Harrison, within the cranium it expands into a small saccus perilymphaticus. Within the ear capsule two small outgrowths occur just proximal to the point where it enters the cranial cavity; the *recessus partis neglecta*, in intimate contact with the pars neglecta, the wall between the two being very thin and a smaller diverticulum, the *recessus partis basilaris*, in close relation to the pars basilaris of the inner labyrinth, with a very thin wall between the two.

The three regions of the perilymphatic sac, that is neglecta, basilaris and sacculus where the membrane separating the perilymph from the endolymph is very thin, are spoken of as "tympanal areas" by Harrison. He suggests that through them vibrations received by the perilymph from the operculum are transmitted to the endolymph. Such vibrations are supposed to set the otolithic crystals in motion in the sacculus and lagena which affect the sensory hairs of the cells covering the maculæ acusticæ and so to the auditory nerve.

The endolymphatic parts of the ear are: semicircular canals with ampullæ, utricle, saccule, lagena, pars basilaris, pars neglecta and ductus endolymphaticus.

The *posterior semicircular canal* is the shortest and the most nearly circular. It is vertical, extending in a posteriolateral direction, arising from the *pars superior utriculi*, just behind the anterior canal, and after almost a completely circular course it re-enters the utricle in its posterior portion, just below the origin of the horizontal canal. The ampulla of this posterior vertical canal is at the ventral end. The *anterior vertical canal* arises from the *sinus superior utriculi* close to the posterior canal and runs in an anterolateral direction. It bends sharply ventrally to join the dorsal side of the *recessus utriculi*, with its ampulla at the anterior end of the canal. The *horizontal canal*, or external canal, arises from the *pars posterior utriculi* between the two ends of the posterior vertical canal. The anterior end bends about and enters the *recessus utriculi* close to the anterior canal, with the ampulla at the anterior end.

The *utricle* is a wide tube extending over the medial part of the saccule. The broad *superior sinus* is its most dorsal portion which gives rise to the anterior and posterior semicircular canals; its anterior end dips vertically to the *recessus utriculi* or the expanded portion which is joined by the ampullæ of the anterior vertical and the horizontal canals. The *canalis utriculo-sacculus* is a small opening between the two parts of the membranous labyrinth. This is at the base of the utricle below the sinus superior. From its mesial wall the pars neglecta is said to extend.

The *sacculus* is a disc-shaped sac, flattened ventro-mesially and containing otolith granules. It is connected to the *sacculus endolymphaticus* by means of the endolymphatic duct. It also opens into the utricle by the utriculo-sacculus duct mentioned above, and into the lagena and pars basilaris. Its very thin lateral wall separates it from the *spatium sacculare*.

The *ductus endolymphaticus* starts from the dorso-mesial part of the saccule close to the *canalis utriculo-saccularis* and passes dorsally medial to the utricle, close to its wall between the origin of the two vertical canals. It passes through the skull at about the level of the sinus superior utriculi into the cranial cavity where it expands into the *sacculus endolymphaticus*.

The *lagena* is small oval sac opening from the median side of the saccule, near its caudal margin. Within is an otolith.

The *pars basilaris* is a small dorso-mesial evagination of the lagena opposite its opening into the saccule.

The sensory areas in the internal ear are: the *cristæ* in the ampullæ of the semicircular canals, the *macula acustica recessus utriculi*, described by Retzius on the floor of this recess, the *macula acustica sacculi* on the mesial wall of the saccule and the *m. a. neglecta* on the dorsal wall of the pars neglecta, the sensory macula

in the *pars basilaris* on much of its surface and the macula of the *lagens* on its mesial wall.

The auditory nerve leaves the acustico-facial ganglion caudially and enters the auditory capsule by three foramina. In some these are not distinct, one, sometimes two, openings being evident, but in some cases where examined more closely three foramina might be seen in the depths of a common pit. There are three divisions of the nerve:

1. The *ramus anterior* which supplies the recessus utriculi and the cristæ of the ampullæ of the anterior vertical canal and the horizontal canal.
2. The *ramus medianus* to the sacculus.
3. The *ramus posterior* to the crista of the posterior vertical canal, to the lagena, the basilaris and the neglecta.

In a *Triturus* examined, but two openings were found for the auditory nerve within the bony capsule although three openings appeared on the brain side of the bone.

The above rather general account is from *Triturus* and *Salamandra*.

The ear capsule differs somewhat in the adults of different groups.

In *Salamandridæ* I found conditions in *Salamandra* much as described above. In *Triturus torosus*, some specimens at least had but one opening from the cranial cavity for the auditory nerve branches, although two or three might be seen in the depths of the pit, but only two were found in the otic cavity. The anterior semi-circular septum or bridge from the mesial wall to the dorsal side of the capsule is well developed. The lateral septum is indicated by a rather wide bridge of bone with a foramen through its wall ventrally. The posterior septum is barely indicated by ridges and depressions in the bone. There was little cartilage except about the operculum.

In *Ambystomidæ* examined, the mesial bridge is well formed, the lateral shelf well developed. There were five openings from the otic capsule to the brain cavity. In large *A. tigranum* both larvæ and adult, there was considerable cartilage in the lateral wall and about the operculum. There was much less cartilage in the otic region of *Dicamptodon* adults examined.

In members of the family *Hynobiidæ*, *Salamandrella* and *Hynobius*, but three foramina for the auditory nerve and the perilymphatic duct were found. The mesial bridge was found well developed with a fairly broad lateral shelf. There was a small area of cartilage in the mesial wall of some and a moderate amount about the opercular opening.

In *Cryptobranchus* and *Necturus* there was very little bony material for bridges or shelves. All of the dorsal and much of the

mesial walls were cartilage with five foramina leading into the cranial cavity.

In *Siren*, there was very little indication of bridges or shelves for the support of the semicircular canals and very little cartilage except about the operculum. There were only two openings, one of which is double, for the ductus perilymphaticus and the auditory nerve, but in the caudal medial margin there were two leading into each other which penetrated the cranium whose use was not determined.

In *Amphiumidae*, the mesial bony ridge is present but narrow, the other supports for the semicircular canals were rather narrow. There were five openings into the cranium; for the ductus endolymphaticus, d. perilymphaticus and the three for the 8th nerve. In addition a pocket or foramen of unknown meaning extends from the cephalic margin toward the optic region but did not seem to penetrate the orbit.

In *Plethodontidae* in no case were more than four openings found from the otic capsule into the cranial cavity. There was little cartilage except about the opercular opening. There were minor variations in the position, development and number of bridges or shelves for the support of the semicircular canals. Some of the variations were as follows:

In *Stereochilus*, a well-developed median and a larger lateral one. In *Boletogrolssa leprosa*, the medial bridge is almost cephalic in position, with a lateral shelf. In *Pseudotriton* there is a well-developed mesial and lateral bridge. In *Hydromantes*, little indication of a lateral shelf or bridge but two divisions of the mesial. In *Hemidactylum*, mesial well-developed bridge, little indication of a lateral shelf or bridge. In *Desmognathus quadrimaculatus*, mesial and lateral bridges well developed. In *Plethodon cinereus*, well-formed mesial and lateral bridges. In *Ensatina* well-developed mesial and lateral bridge and shelf with a narrow bone from one to the others.

The above description applies to the bony inclosure of the membranous labyrinth of the semicircular canals. Usually when there are no bony shelves and bridges on the outer and inner sides above, these are formed in cartilage, sometimes with slight support from the bony inner wall of the capsule.

The blood supply to the internal ear is quite marked: The posterior division of the cerebral carotid artery has small branches which unite to form a median basilar artery which runs along the middle line of the medulla. From this last an auditory branch is given off on each side. Each of these on each side divides into at least two branches which follow the branches of the auditory nerve into the interior of the bony capsule and supply the perilymphatic and the endolymphatic membranes. Capillary networks are especially marked near the three ampullæ and parts of the sacculus and

utriculus. The lagina and pars basilaris have less abundant blood supply than the median wall of the sacculus and the pars neglecta. Blood apparently leaves the capillaries of the internal ear by way of a vessel following the ductus endolymphaticus through into the cranial cavity to join the plexus of the fourth ventricle of the brain.

The columella and operculum have been described in earlier papers. The former is especially developed in larval and aquatic forms and connected with the suspensorium. In Siren it is associated with the branchial region. In more definite land forms the operculum is usually more evident with a plate of cartilage or bone which appears to fill the fenestra vestibuli. It is usually attached to the edges of the auditory capsule opening by dense membrane and is probably developed from the wall of the ear capsule. It is attached to the shoulder girdle by a muscle which has been called *M. opercularis*.

According to Dunn '41, this is not homologous with the muscle recognized by Gaup as *levator scapulæ superior pars opercularis* in the frog. However, it is convenient to call it the opercularis muscle although its derivation is not the same among salamanders where the muscular connection between operculum and shoulder girdle is made either by the entire *levator scapulæ* or by a slip from the *cucullaris major*.

It differs in size and form in different species. For instance, in Cynops and Triturus it is very broad and largely attached to cartilage, in Ambystoma opacum it is broad and entirely attached to the cartilage of the shoulder girdle. In both of these it is very broad at the scapular attachment. In Plethodon and Desmognathus it is attached near the glenoid fossa to bone and in each case is very long and narrow.

In the development of the internal ear, before hatching the auditory capsule is a simple sac. In some cases it is pointed somewhat dorsally, suggesting the ductus endolymphaticus. This is not obvious in all although prominent in many. Apparently the early connection with surface epithelium is not always retained and the ductus endolymphaticus comes to be a new structure which is often not marked until quite a late stage in the ear development.

In later stages, the simple auditory capsule becomes slightly sacculated before sacculus, utriculus and semicircular canals are more than suggested. The perilymphatic space and sac begins as a lateral outgrowth from the common body of the sacculus and utriculus.

The semicircular canals are formed very early by partial separations from the sacculo-utricular capsule, more evident first on the latero-dorsal side, but shallow pockets show the beginnings of all three about the time of hatching or a little before, when the sacculus and utriculus are not sharply differentiated.

Sensory spots are early recognized by regions of thickened epithelium, first mesially and ventrally. First the cells in these areas

are longer, then two layers are formed; a condition which may be retained to the adult although often the sensory spots have five or more layers of cells. In any case the central surface cells come to have a different appearance and some of them develop hairs or cilia on their inner surfaces. Aside from the sensory areas which develop in the utriculus wall, several places in the sacculus and in the three ampullæ of the semicircular canals, the wall of the membranous labyrinth remains a single layer of cuboidal or flatter cells. They may be very flat in the ductus endolymphaticus in the adult and in the perilymphatic membranes. The walls of all but the last may be strengthened by a rather dense basement membrane and loose connective tissue cells. The pars basilaris and the pars neglecta may have two or more layers of cells in their central areas. In all the specimens examined the pars basilaris seemed much less important than the pars neglecta as judged by structure, nerve supply and blood supply.

SOME CONCLUSIONS

1. There are from three to five foramina in the auditory capsule for the passage of two to three branches of the auditory nerve, the ductus perilymphaticus and the ductus endolymphaticus. In addition there are some special blood vessel foramina in Siren and in the shelf of the lateral canal in Triturus and some others.
2. The opercular muscle differs greatly in different genera, being long and slender in some, shorter and triangular in others, with slightly different attachments to the shoulder girdle.
3. The blood enters the ear capsule by two or three blood vessels which accompany branches of the auditory nerve.
4. The blood leaves the internal ear along the ductus endolymphaticus to join the network over the medulla oblongata.
5. The blood vessels form the most marked networks about the ampullæ, in the sacculus and in the pars neglecta.
6. The perilymphatic membrane in places has a network of two levels of blood vessels, especially on the dorsal side.
7. The pars basilaris and the lagina have far less marked blood supply than the main part of the sacculus and the pars neglecta.
8. According to the nerve supply and the blood supply as well as structure the pars neglecta is far more important than the pars basilaris.
9. The sensory spots in utriculus, sacculus, semicircular canal ampullæ and pars neglecta have the best blood supply, and nerve supply. The lagena has a good nerve supply but not as good a blood supply as the other spots mentioned above.
10. The ear develops at different rates in different species and in individuals of the same species. The ductus endolymphaticus

may not be well marked until later stages. The sacculus and utriculus may be indicated early without wide separation for some time. Semicircular canals may be indicated quite early before really separated from the common sac. The perilymphatic space shows in the beginning as an outgrowth from the common, but somewhat sacculated, otic capsule.

11. The sensory areas are early indicated by thickenings of the epithelium of the capsule, first ventrally, then mesially, then as spots in utriculus and the region of future ampullæ. After a thickening of the cell areas by enlargement of the cells, two or more layers develop with some hairs or cilia forming on the surface of more central cells of each patch.

12. In general before hatching the internal ear is not greatly differentiated. The balancers or cirri originate near the auditory capsules and remain until the ear is quite well developed, or when the hind legs begin to be evident or a little later. Usually before the hind legs are functional the ear is much like the adult.

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EXPLANATION OF PLATES

PLATE 11

Views of the interior of the bony ear capsules of salamanders. The medial side is at the top of the page; the upper foramen is for the ductus endolymphaticus, the other two, three or four are for the entrance of two or three branches of the auditory nerve and for the ductus perilymphaticus. The dotted area represents the cavity. A bony bridge is shown on one or both sides. Only bone is indicated, but in many cases some cartilage forms a part of the mesial wall and lateral sides supplementing the bony shelves to partly inclose the two more dorsal portions of the semicircular canals, on the outside and on the inside above. The cephalic end is to the left in all the figures. Scale equals 1 mm.

1. *Dicamptodon*. 2. *Boletoglossa*. 3. *Ambystoma*. 4. *Hydromantes*. 5. *Desmognathus*. 6. *Ensatina*. 7. *Salamandrella*. 8. *Hynobius*. 9. *Stereochilus*. 10. *Amphiuma*. 11. *Aneides*. 12. *Siren*. 13. *Cryptobranchus*. 14. *Necturus*.

PLATE 12

1 and 2. Cranial views of auditory area showing foramina leading to the internal ear and some others. 1. *Triturus*. 2. *Ambystoma*.

3, 4 and 5. Inside views of the bony capsule of *Triturus*.

3. From above looking into cavity, lateral side down, mesial up. Three foramina shown for auditory nerve branches and ductus perilymphaticus. A bit of the dorsal roof is left with mesial bony bridge and the dark area at the center position of the opercular opening.
3. Similar view as the last more tipped showing lateral shelf with its foramen, three openings for the auditory nerve and ductus perilymphaticus and above the opening for the ductus endolymphaticus.
5. View looking into the dorsal inner surface of the bony capsule, showing two partial bony canals for semicircular canals and two foramina in the lateral shelf. Scale, 1 mm.

6-9. Opercular muscles in 6. *Amblystoma*. 7. *Desmognathus*. 8. *Plethodon glutinosus*. 9. *Cynops* and *Triturus*.

10. Opercular connection with branchial arch in a young siren.

Blood and nerve supply to parts of the internal ear.

PLATE 13

1, 2, 3. Dorsal lateral and mesial views of the membranes labyrinth of *Triturus*. 4. Blood supply to pars neglecta and three neighboring regions, enlarged. 5. Nerve and blood supply to utriculus and two ampullae.

6. Two layers of blood vessels in the dorsal part of the perilymphatic

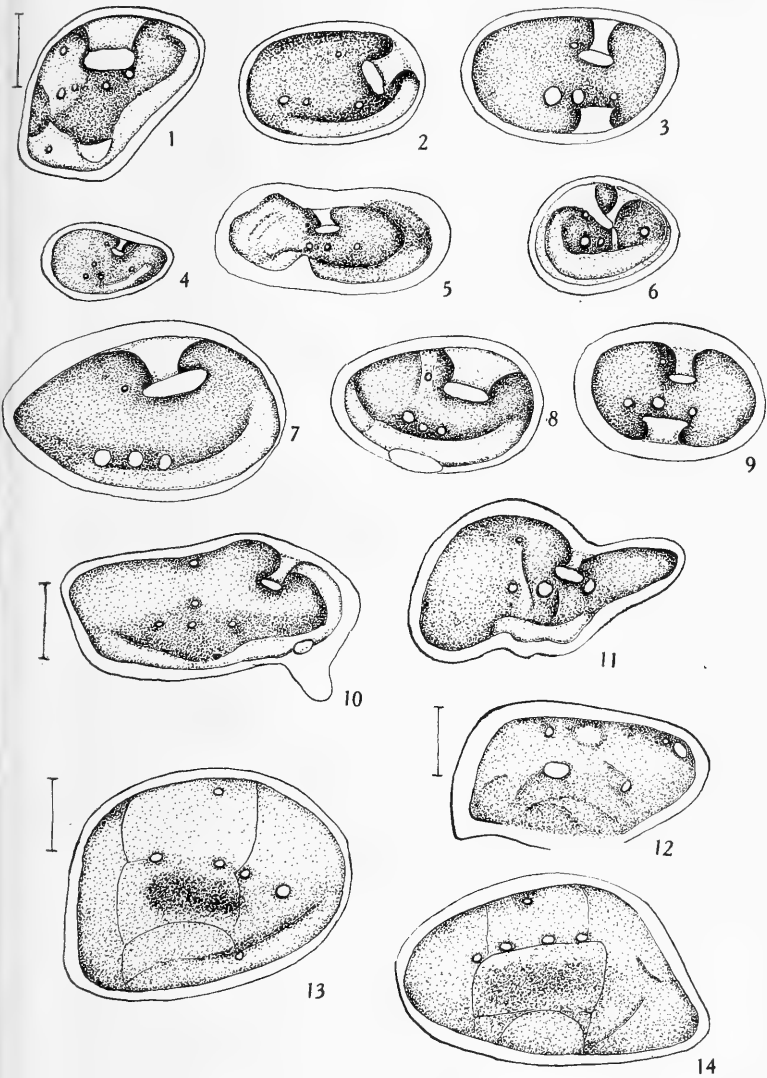


PLATE 11

sac in adult *Amphiuma*. 7. Chief nerves and entering and leaving blood vessels in the saccular region of *Siren*.

PLATE 14

1-6. Dissections of membranous labyrinth of *Triturus*.

1. Side view of membranous capsule of a 9 mm. unhatched embryo.

2. Top view of a 12 mm. just hatched larva, view from above. It is really one sac but partly divided. Mesial side to the right. The utriculus on this side. 3. 13 mm. larva, view from above utriculus at the right with suggestions of semi-circular canals. 4. Mesial view of the last, showing sacculus below, ductus endolymphaticus with utriculus arched above. 5 and 6. Similar views of a 14 mm. larva. Line equals 1 mm.

7. Section of wall of membranous labyrinth; cuboidal lining cells, basement membrane, small blood vessel with a blood corpuscle and connective tissue cell. 8. Section of the wall of ductus endolymphaticus in adult. Scale for 7 and 8 equals one hundredth mm.

9. Longitudinal section through pars neglecta, ductus perilymphaticus and at the bottom pars basilaris. 10. Longitudinal section through the center of the pars neglecta. This and 9, from young *Desmognathus fusca* about 40 mm. long. Scale for 9 and 10, one hundredth mm.

13 to 18. Reconstructions of ears of larval salamanders, caudal views, somewhat diagrammatic, especially 18. Dorsal side up, mesial side to the left. Lateral extensions in 15 and 16 part of the utriculus. The more ventral or lower extension to the outside or to the right, beginnings of the perilymphatic sac. 19. *Triturus* of 11 mm. 14. *Ambystoma maculatum* about 13 mm. length. 15. *A. Tigranum* of 20 mm. Lateral lobe beginning of utriculus 16. *A. maculatum* of 15 mm. 17. *Desmognathus fusca* before hatching. Upper outgrowth utriculus, lower perilymphatic sac. 18. *Triturus* of 14 mm. lateral outgrowths of utriculus above, perilymphatic sac below. Suggestion of semicircular canals diagrammatic.

19. Section of *Necturus* of 20 mm. showing three ear parts with ductus endolymphaticus leading into brain cavity.

13 to 19 scale equals one-tenth mm.

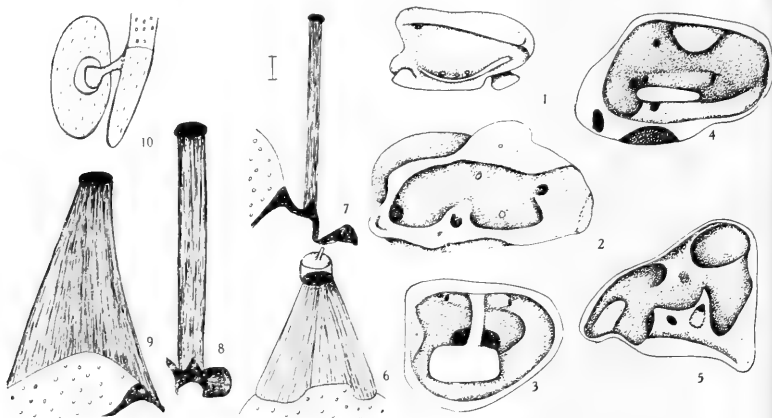


PLATE 12

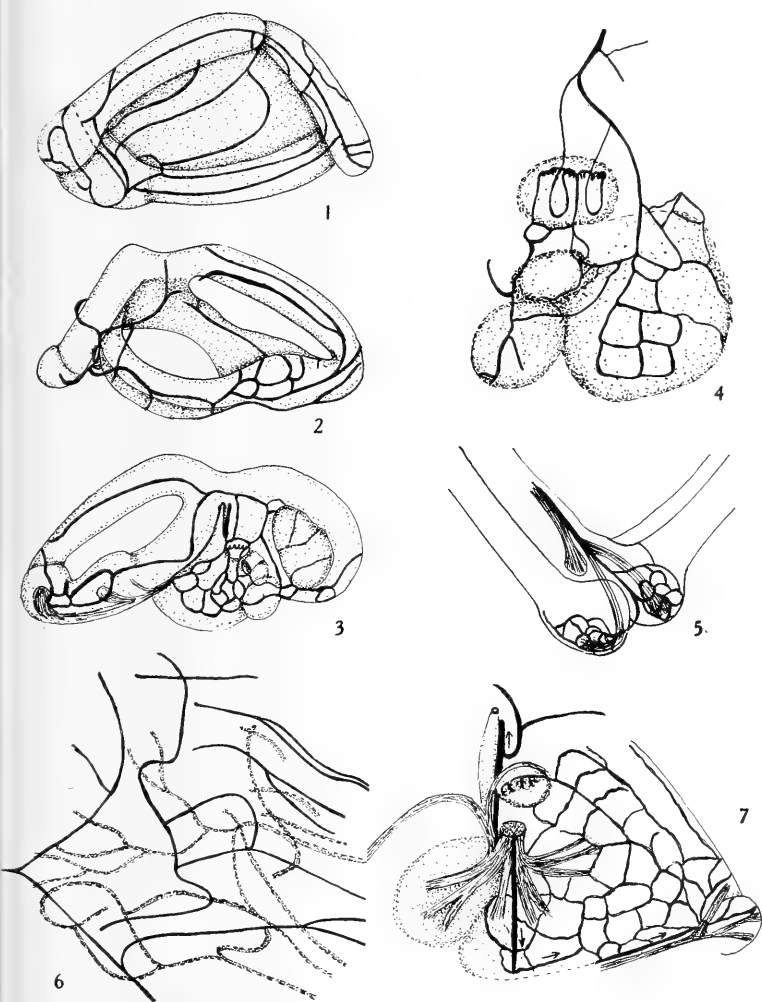


PLATE 13

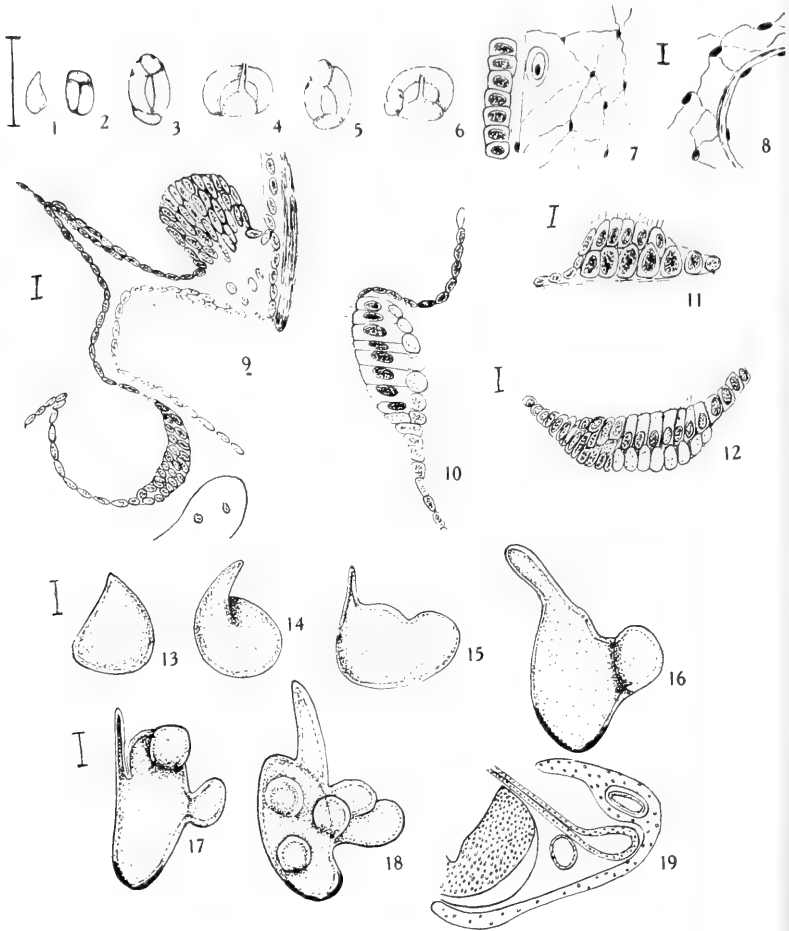


PLATE 14

MITES OF THE GENUS NEOPHYLLOBIUS

By E. A. MCGREGOR

Mites of the genus *Neophyllobius* in the past have been included in the family Tetranychidæ. Rather recently doubt has arisen among a few workers, including the present author, as to the correctness of this family placement of *Neophyllobius*. Little, if anything, has been known regarding the feeding habits of these mites.

In recent correspondence, Pence¹ related in detail certain laboratory experiments with *Neophyllobius* mites and *Latania* scale crawlers, condensed as follows: ". . . When a crawler is encountered . . . it is set upon by the mite which quickly inserts its beak into a vulnerable spot . . . some opiate effect in quickly administered. The crawler . . . relaxes and allows its body juices to be extracted without struggle."

Baker,² in recent correspondence, expressed doubt that *Neophyllobius* belongs in the Tetranychidæ. He believes that these mites belong in the Stigmæidæ "in the broad sense." Baker states that observations on several undescribed genera have caused him to undertake a re-examination of the mite complex embracing Raphignathidæ, Stigmæidæ, and Caligonellidæ. The available information seems to justify the transfer of *Neophyllobius* from the family Tetranychidæ to the family Stigmæidæ, which is here done.

GENUS NEOPHYLLOBIUS Berlese

Neophyllobius Berlese, 1886, Acari dan. Piante colt., p. 19.

GENERIC CHARACTERS. (Female.) Body small, compressed dorsoventrally, rotund to ovate, suture between cephalothorax and abdomen rarely visible. Dorsal integument with striæ somewhat tortuous. Dorsal body setæ peglike, lanceolate, or clavate, obscurely to conspicuously setose, often borne on tubercles. Rostrum short, at times hidden. Palpi short, slender, 5-segmented, without the strong, talonlike claw on penultimate segment, but with two or more hairs, one of which may be bladeliike. Manibular plate present; stylets needlelike, recurved basally. Legs long, exceeding the body; segments with few hairs, mostly arising from tubercles; patellæ at times with a whiplike hair; patellæ I and II often with a barely visible spine; tibiæ often bearing a very minute, naillike seta subterminally; tarsi much shorter than tibiæ, often swollen at middle, and bearing a minute, spindle-shaped seta; duplex setæ lacking. Onychium bearing two claws, between which is a pulvillus bearing two rows of tenent hairs. Male unknown.

GENOTYPE. NEOPHYLLOBIUS ELEGANS Berlese.

¹Roy J. Pence, University of California, Los Angeles.

²E. W. Baker, Bureau of Entomology and Plant Quarantine, Washington, D. C.

KEY TO SPECIES OF NEOPHYLLOBIUS

1. Patella I bearing a long, whiplike hair, as long or longer than the tibia 2
 Patella I with seta (or setæ) much shorter than tibia I 3
2. Dorsum of body bearing 15 pairs of setæ; whiplike hair on patella reaching beyond tip of tarsus—*lamimani*, new species
 Dorsum of body bearing 14 pairs of setæ; whiplike hair on patella reaching only to tip of tibia—*americanus* Banks
3. Dorsum of abdomen with 3 pairs of minute submedian setæ; femora I with setæ mostly longer than intervals to setæ next beyond in line—*virginiensis*, new species
 Abdomen with none of submedian setæ minute; femora I with setæ mostly shorter than intervals to setæ next beyond in line (one exception) 4
4. Dorsal body setæ clavate to obovate—*floridensis*, new species
 Dorsal body setæ not clavate to obovate 5
5. Patellæ bearing two easily visible setæ, these shorter than the segment—*agrifoliæ*, new species
 Patellæ bearing a single easily visible seta, these longer than the segment 6
6. Dorsum of body with 17 pairs of setæ, these rodlike, densely bractate—*texanus*, new species
 Dorsum of body with 15 or 16 pairs of setæ, these not rodlike or densely bractate 7
7. Femora bearing thickly lanceolate setæ 8
 Femora bearing linear-lanceolate setæ 9
8. Seta on patella I three times as long as the segment; setæ at caudal margin of body blunt-tipped—*mexicanus*, new species
 Setæ on patella I about twice as long as segment; caudal setæ sharp-tipped—*sierræ*, new species
9. Patella II bearing a hair nearly as long as tibia II; patella IV bearing a hair longer than tibia IV—*burrellis*, new species
 Patella II with hair only two-fifths as long as tibia II; patella IV bearing a hair distinctly shorter than tibia IV—*summersi*, new species.

NEOPHYLLOBIUS AGRIFOLIÆ, new species

Plate 15

FEMALE. Body from above rotund. Dorsum with striæ mostly transverse, but tortuous near margins. Seventeen pairs of strictly dorsal body setæ, including those along caudal margin; setæ thick-lanceolate, shortish, very conspicuously setose, each failing to reach or barely surpassing base of seta next behind, distributed as fol-

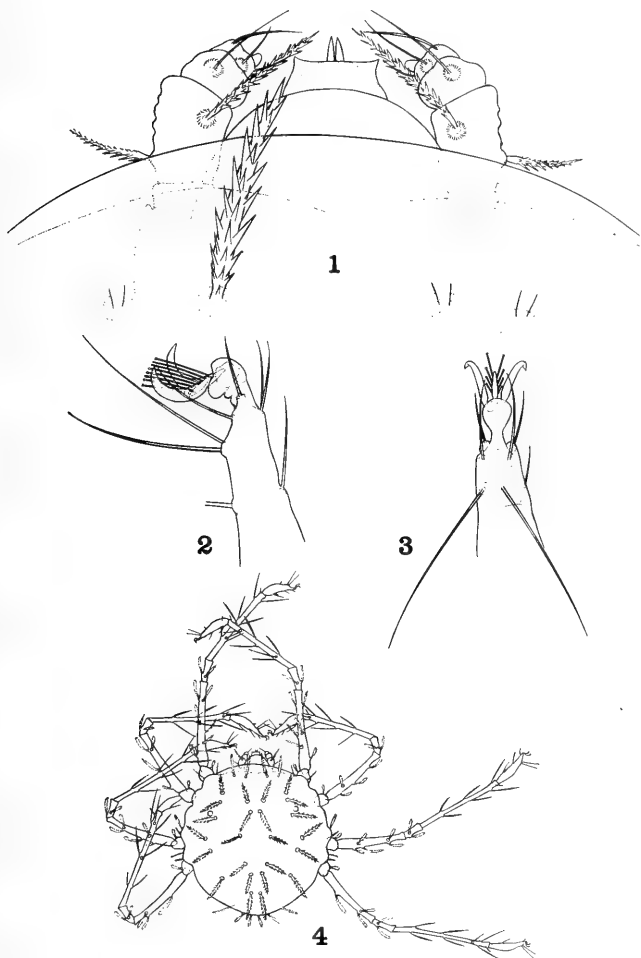


PLATE 15

NEOPHYLLOBIUS AGRIFOLIAE, new species. 1, front of cephalothorax, with frontal setæ, palpi, etc., dorsal view; 2, tip of tarsus, lateral view; 3, tip of tarsus, dorsal view; 4, female mite, dorsal view.

lows: Four submarginally along front of body; seven sublaterally each side between coxæ I and caudal margin; 6 submedian pairs between coxæ II and hind margin; 4 along caudal margin. Rostrum and palpi small. Mandibular plate oval, rounded in front. One perfect and one imperfect eye cornea each side mesad of coxæ II. Second segment of palpus the largest, bearing dorsally a strong, plumose seta and laterally a smaller similar seta; last segment de-

flexed from preceding segment (position of specimens prevented a critical study of the "thumb"). Legs all longer than body, sparsely provided with shortish hairs; setae on the tibiae and tarsi linear-lanceolate, those on other segments subclavate and distinctly setose, each shorter than interval to seta next beyond. Tarsi somewhat swollen, much shorter than tibiae, each bearing distally 2 strong, simple claws, and between them a pulvillus lined on each side with a pectinate series of tenent hairs; tarsi I and II bearing dorsodistally a pair of long, non-duplex hairs, and close behind them a very small, evidently swollen seta. Patella bearing 2 subclavate, setose setae, shorter than the segment, and a barely visible spine. Male not known.

TYPE MATERIAL. U. S. Nat. Museum No. 1746. One specimen, collected by B. L. Boyden, Sept. 3, 1938.

TYPE LOCALITY. South Pasadena, California.

DISTRIBUTION. Known only from type locality.

HABITAT. Live oak (*Quercus agrifolia*).

NEOPHYLLOBIUS AMERICANUS Banks

Plate 16

NEOPHYLLOBIUS AMERICANUS Banks, 1906, Ent. Soc. Wash. Proc. 7, p. 133; U. S. D. A. Rpt. 108, p. 38.

FEMALE. Body from above, ovate. Dorsum with 14 pairs of linear-lanceolate setae, each longer than interval to seta next behind; a pair over base of palpi; 5 along and within each lateral margin between coxae I and IV; 7 submedian pairs on abdomen between usual position of main suture and caudal margin; all dorsal body setae sparsely setose. Last segment of palpus evidently with one terminal and 3 subterminal setae; preceding segment evidently without a claw. Legs much longer than body. Patella very short, bearing a whiplike hair about as long as the tibia; patellae I and II bearing also an almost invisible spine. Tarsi much shorter than tibiae, swollen near midpoint; onychium with 2 claws and between them a pulvillus pectinate on each side. Tarsus I bearing subterminally a pair of long, non-duplex hairs, and near base of segment a small, swollen sensory seta. Male not known.

TYPE MATERIAL. U. S. Nat. Museum No. 1745, March 15, 1901.

TYPE LOCALITY. Orchard, Alabama.

DISTRIBUTION. Known only from type locality.

HABITAT. Oak.

The foregoing description is based on sketches by E. W. Baker, made from type specimens in the U. S. National Museum. Banks' figure of this mite also was taken into account.

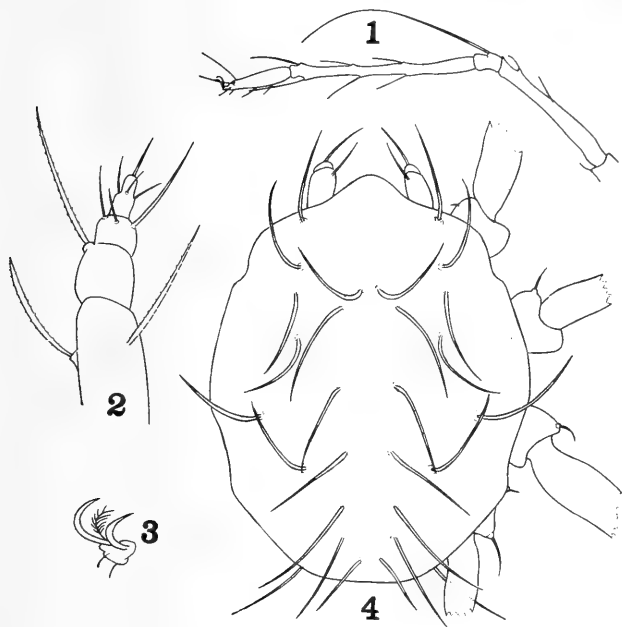


PLATE 16

NEOPHYLLOBIUS AMERICANUS Banks. 1, leg IV; 2, palpus; 3, onychium with claws and pulvillus; 4, dorsum of body showing dorsal setae and base of right legs I-IV (drawn from sketches furnished by Baker from material in the U. S. National Museum).

NEOPHYLLOBIUS BURRELLIS, new species

Plate 17

FEMALE. Body subovate, probably¹ with 16 pairs of linear, minutely bracteolate dorsal body setae, only slightly attenuate terminally, all but the 3rd, 4th, and 5th submedian setae slightly longer than interval to seta next behind, distributed as follows: One frontal seta over each palpus; 6 sublateral setae along each side; a fringe of 6 shorter setae at caudal margin; probably¹ 6 pairs of setae along the dorsal crista. Nearly all body and leg setae arising from tubercles. Rostrum and palpi inconspicuous. Legs all longer than body, sparsely provided with mostly shortish, linear-lanceolate hairs (femora II, III, and IV, bearing linear, bracteolate hairs). Two submarginal eye corneae each side just anteriolaterad of base of

¹In the single specimen, a mass of opaque body material obscures the area where 3 pairs of submedian setae might otherwise be visible.

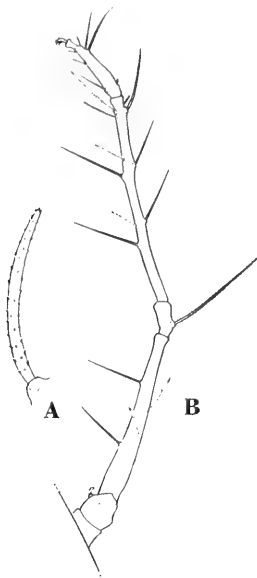


PLATE 17

NEOPHYLLOBIUS BURRELLIS, new species. A, sublateral, abdominal seta; B, right leg I from above.

third submarginal seta. Segment II of palpus the largest, bearing two setae, one of which is densely setose and longer than the segment. Patellae all bearing a linear-lanceolate hair which becomes progressively longer from patella I to IV; this hair on patella I much longer than the segment, and about five-ninths as long as tibia I; that on patella II nearly as long as tibia II; that on patella III equalling the tibia; that on patella IV one-fifth longer than the tibia. Patellae I and II also with a nearly imperceptible spine. All tibiae terminally bearing a short, naillike seta. Tarsi somewhat swollen, much shorter than tibiae, each bearing terminally two strong, simple claws, between them a pulvillus which bears a double row of tenent hairs. Tarsi I and II each bearing sub-basally a minute, sausage-shaped seta.

TYPE MATERIAL. U. S. National Museum No. 1896. A single specimen collected by R. W. Burrell, June 13, 1949.

TYPE LOCALITY. Yakima, Wash.

DISTRIBUTION. Known only from type locality.

HABITAT. Bark of apple tree.

NEOPHYLLOBIUS FLORIDENSIS, new species

Plate 18

FEMALE. Body subovate, with 15 pairs of widely clavate to obovate, petiolate dorsal body setæ, all but the frontals much shorter than interval to seta next behind, distributed as follows: One clavate frontal seta over base of each palpus; 7 ovate-clavate submarginal setæ along each side; a fringe of 4 ovate-clavate setæ at caudal margin; 5 pairs of ovate-lanceolate setæ along the median crista. Nearly all body and leg setæ arising from tubercles. Rostrum and palpi inconspicuous. Legs all longer than body, legs I and IV the longest. Palpus with segment II the largest, bearing two plumose setæ, the longest seta longer than the segment. Legs bearing relatively few linear-lanceolate to spatulate hairs, the latter plumose. Patellæ all bearing an oblanceolate, densely setose hair, longer than the segment, but much shorter than tibia; patella I and II bearing, in addition, an almost imperceptible spine. All tibiæ terminally with a short, naillike seta. Tarsus I and II sub-basally with a small, clavate seta. A pair of eye corneæ dorsally between bases of coxæ I and II.

TYPE MATERIAL. U. S. National Museum No. 1897. Four specimens collected by D. C. Thurman, Feb. 4, 1948.

TYPE LOCALITY. Dupont Road, Duval County, Fla.

DISTRIBUTION. Known only from type locality.

HABITAT. Spanish moss.

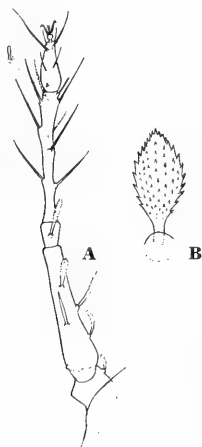


PLATE 18

NEOPHYLLOBIUS FLORIDENSIS, new species. A, right leg I, ventral view; B, a dorsal, submedian seta.

NEOPHYLLOBIUS LAMIMANI, new species

Plate 19

FEMALE. Body from above ovate-orbicular. Dorsum with 15 pairs of setae, including those on caudal margin; all scythe-blade shaped, sparsely appressed setose, distributed as follows: A pair on frontal margin between palpi, 5 submedian pairs, a pair opposite middle of mandibular plate, one over inner end of coxae I, one each mesad of coxae II, III, and IV, 2 each side between coxae IV and caudal tip, 4 along caudal margin. Rostrum and palpi rather inconspicuous. Mandibles short, styliform, recurved basally. Palpi 5-segmented, segment II the longest; last segment small, thumb-like, subtended from fourth segment which bears a bladelike seta (but no claw); "thumb" terminally with 2 setae nearly as long as the

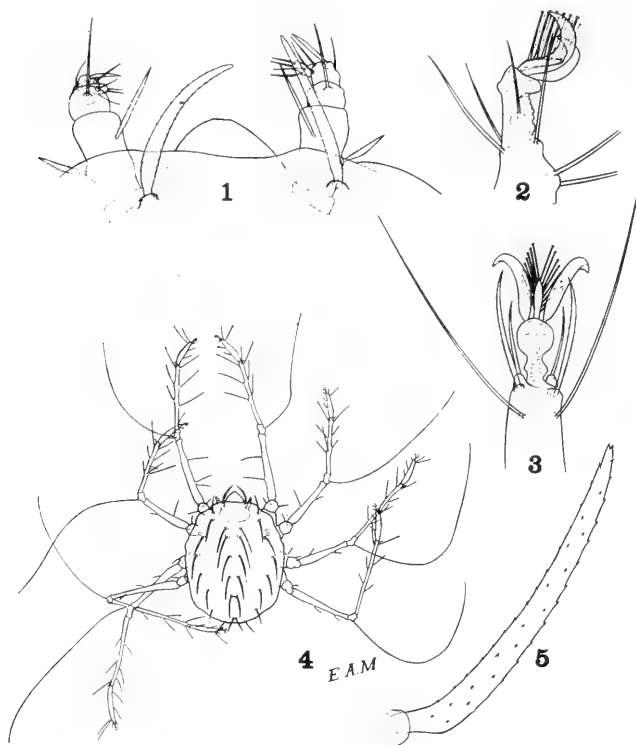


PLATE 19

NEOPHYLLOBIUS LAMIMANI, new species. 1, front of cephalothorax with palpi, frontal setae, mandibular plate; 2, tip of tarsus, lateral view; 3, same, dorsal view; 4, female mite, dorsal view; 5, dorsal body seta.

segment, and 2 sub-basal setæ. Mandibular plate short, ovate, sharply rotund in front. Legs all much longer than body, legs I and IV the longest; legs bearing relatively few shortish, lanceolate, minutely barbed hairs; patella of each leg with a long, whiplike hair reaching well beyond tip of tarsus; patella I and II also bearing a minute spine; relative lengths of segments of leg I as follows: Coxa, 10; trochanter, 14; femur, 89; patella, 14; tibia, 85; tarsus, 35; tarsi somewhat swollen at middle. Onychium bearing 2 stout, simple, sickle-shaped claws, and between them a pulvillus bearing along each side a pectinate series of tenent hairs about equaling claws. Tarsus I bearing subterminally a pair of longish, non-duplex hairs, also a small, swollen sensory seta near base of segment. Tibiæ subterminally each bearing a minute, naillike seta.

TYPE MATERIAL. Type, California Acad. Sciences, No. 5695; paratype, U. S. Nat. Museum No. 1749.

TYPE LOCALITY. Fresno, Calif., collected by E. W. Baker.

DISTRIBUTION. Dinuba, Davis, Fresno and Planada, Calif.

HABITAT. Lichen on fig tree, grape and salt-grass.

NEOPHYLLOBIUS MEXICANUS, new species

Plate 20

FEMALE. Body ovate. Rostrum and palpi inconspicuous. Fifteen ? pairs of dorsal body setæ, mostly linear-lanceolate, remotely setose or bracteolate, distributed as follows: One frontal seta over each palpus; 7 submarginal setæ along each side; 5 ?¹ submedian pairs of setæ along the dorsal crista; 4 short setæ on caudal margin. The frontal, first and second submarginal setæ, and the first and last submedian setæ longer than interval to base of seta next behind; other body setæ shorter than this interval. Two corneæ each side immediately anterio-laterad of third sublateral seta. Second segment of palpus the largest, bearing two lanceolate, densely setose hairs, the inner hair longer than the segment. Legs all longer than body. Hairs on tibiæ and tarsi sparse, shortish, linear-lanceolate; hairs on coxæ and femora short, plumose. Tibiæ subapically each with a short naillike seta. Tarsi all somewhat swollen, much shorter than tibiæ; all bearing terminally two strong, simple claws, and between them a pulvillus lined each side with a series of short tenent hairs; tarsi I and II each sub-basally with a minute, clavate seta. Patellæ all bearing a linear-lanceolate hair; that on patella I about two-thirds as long as tibia I, than on patella II about one-half as long as tibia II, that on patella III nearly as long as tibia III, that on patella IV slightly longer than tibia IV. Patellæ I and II each bearing also an almost imperceptible spine.

¹The area normally bearing the third submedian setæ is opaque in the single specimen; it is assumed that these setæ are present.

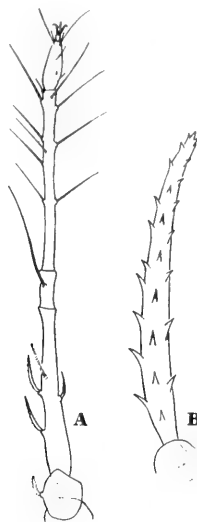


PLATE 20

NEOPHYLLOBIUS MEXICANUS, new species. A, right leg I, dorsal view; B, first submedian, dorsal seta.

TYPE MATERIAL. U. S. National Museum No. 1895. A single specimen, collected Nov. 17, 1948, by A. Williamson.

TYPE LOCALITY. "Mexico" (intercepted at Brownsville, Tex.).

DISTRIBUTION. Known only in the above collection.

HABITAT. Avocado budwood.

NEOPHYLLOBIUS SIERRÆ, new species

Plate 21

FEMALE. Body from above subovate, margin somewhat crenulate, somewhat truncate in front. Fifteen pairs of lanceolate to spindle-shaped dorsal body setae, distributed as follows: A pair near front margin, one over each palpal base; two each side over coxæ I; one near margin behind each coxa II; one each over coxæ III and IV; two sublaterally between coxæ IV and caudal end; four along caudal margin; five submedian pairs; all arising from tubercles, and longer than interval to base of seta next behind. Rostrum and palpi short. Legs all longer than body, legs I and IV longest. Tarsi much shorter than tibiae, somewhat swollen. Mandibular plate notched in front. Second segment of palpus the largest, bearing a strong, bladelike seta and a similar smaller seta; fourth segment without a hook, but bearing a strong, bladelike seta; last segment of palpi

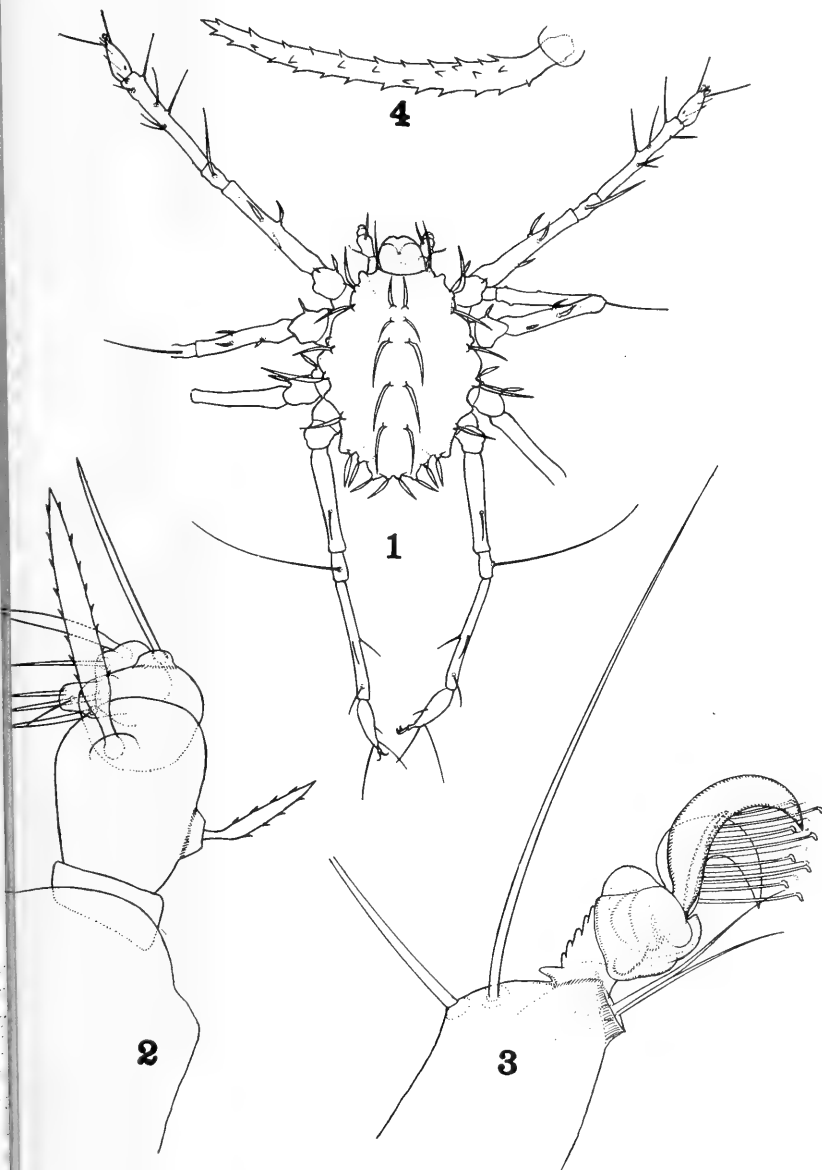


PLATE 21

NEOPHYLLOBIUS SIERRAE, new species. 1, female mite, dorsal view (only base of legs II and III shown); 2, right palpus from above; 3, tip of tarsus, lateral view; 4, a dorsal body seta.

deflexed, evidently bearing three setae near tip. Legs with setae of last three segments linear-lanceolate; other segments with setae mostly short, thickened at middle, each shorter than interval to seta next beyond in line. Only one well-developed seta on patella, those of legs III and IV whiplike, that on patella IV longer than tibia IV; hair on patellae I and II much shorter than respective tibiae. Patellae I and II each bearing also an almost invisible spine. All tibiae each bearing subterminally a short, naillike seta. Tarsus with onychium bearing two stout, simple claws and between them a pulvillus with a pectinate series of tenent hairs along each side; tarsus I bearing dorsodistally 2 long, non-duplicate hairs, and near base of segment a short, sausage-shaped sensory seta.

Male not known.

TYPE MATERIAL. U. S. Nat. Museum No. 1801. Two specimens collected by E. W. Baker.

TYPE LOCALITY. Camp Nelson, Calif.

DISTRIBUTION. Known only from type locality.

HABITAT. Incense cedar (*Libocedrus decurrens*).

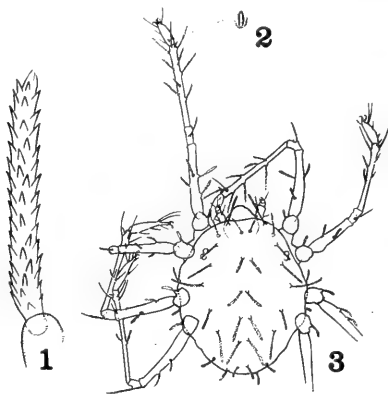


PLATE 22

NEOPHYLLOBIUS TEXANUS, new species. 1, dorsal body seta; 2, sensory seta on tarsus I of female; 3, female mite, dorsal view.

NEOPHYLLOBIUS TEXANUS, new species

Plate 22

FEMALE. Body from above oval; suture between cephalothorax and abdomen not visible; two eye corneae each side over coxae II; striations on dorsum mostly tortuous. Rostrum small, ovate. Palpi inconspicuous; second segment with a very setose hair dorsally

slightly longer than the segment, and a similar smaller hair laterally; third segment with a lanceolate hair above; terminal segment with 3 or 4 small setæ. Seventeen pairs of rodlike dorsal body setæ, as follows: One near front margin over base of each palpus, 2 each side over bases of legs I, one close behind eye, 1 over coxa III, 1 over coxa IV, 1 on lateral margin just before and 1 just behind trochanter III, 1 postmediad of each coxa IV, 4 along the caudal margin, 6 submedian pairs from over the mandibular plate to near the caudal margin; dorsal setæ failing to reach, or only slightly surpassing bases of setæ next behind; dorsal body setæ and most of the leg hairs borne on small tubercles. Legs all longer than body to front of cephalothorax, legs I almost one-half again as long as body. Relative lengths of segments of leg I as follows: Trochanter, 5; femur, 21; patella, 5; tibia, 24; tarsus, 9. All tarsi swollen, each bearing dorso-terminally 2 lanceolate, non-duplex hairs, these fully half as long as the segment; tarsi I and II each bearing near base a minute, sausage-shaped seta (probably a sensory organ). Patellæ bearing middorsally a single noticeable, oblong-lanceolate, strongly setose hair, about twice as long as the segment; patellæ I and II also bearing each a minute, barely visible spine; tibiæ and tarsi with sparse, shortish, setose, lanceolate hairs; trochanters and femora bearing shortish, oblong to spatulate, setose hairs. Tip of tarsi with 2 strong, hooked claws and a median pulvillus, the latter bearing along each side a series of short tenent hairs (the number difficult to observe). The male is unknown.

TYPE MATERIAL. U. S. Nat. Museum No. 1747; one female and one larva collected Sept. 1, 1937, by L. D. Christenson.

TYPE LOCALITY. Tyler, Texas.

DISTRIBUTION. Known only from type locality.

HABITAT. Peach.

NEOPHYLLOBIUS SUMMERSI, new species

Plate 23

FEMALE. Color cherry, with crista white. Body from above ovate. Dorsum with striæ irregular; areas embracing base of dorsal setæ less distinctly striate, constituting the plates or shields of some authors (see Plate 23). Fifteen pairs of linear-lanceolate, coarsely serrate dorsal body setæ, mostly longer than interval to seta next behind, distributed as follows: A frontal seta over base of each palpus; 7 submarginally along each side; 5 pairs of submedian setæ; 4 short setæ subcaudally. One perfect and one imperfect eye cornea each side sublaterally, just in front of third sublateral seta. Rostrum and palpi short, often hidden. Second segment of palpus the largest, bearing 3 lanceolate, setose setæ. Legs

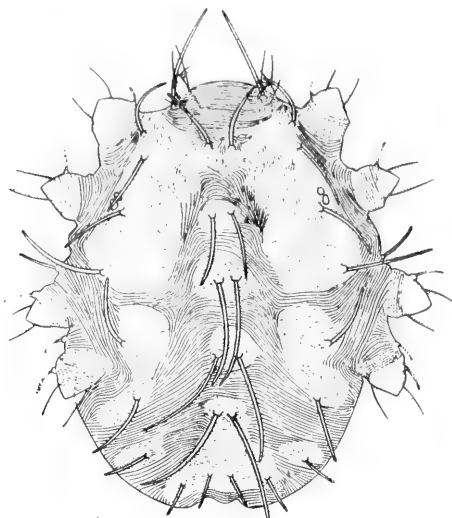


PLATE 23

NEOPHYLLOBIUS SUMMERSI, new species. Dorsal aspect of body, showing dorsal setae, base of legs, and pattern of striations in the dorsal integument.

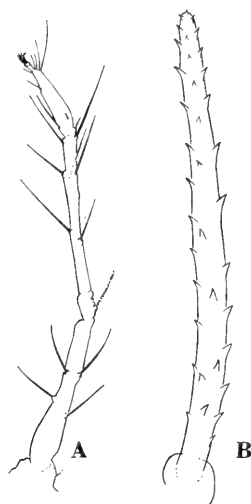


PLATE 24

NEOPHYLLOBIUS SUMMERSI, new species. A, leg I of female; B, submarginal, dorsal body seta.

all longer than body, sparsely provided with shortish, linear-lanceolate hairs. Tarsi swollen, much shorter than tibiae, each bearing terminally two strong, simple claws, and between them a pulvillus lined each side with a pectinate series of tenent hairs. Tarsi I and II each bearing subbasally a minute, finger-shaped seta. All tibiae bearing distally a short, naillike seta. Patellae I and II each bearing a linear, slightly thickened, setose hair, nearly twice as long as the segment, and an almost imperceptible spine; linear hair on patella II only two-fifths as long as tibia II; the linear hair longer on patellae III and IV, but shorter than the tibia of these legs.

TYPE MATERIAL. U. S. National Museum No. 1898. Four specimens collected by E. Cott, January, 1948.

TYPE LOCALITY. One and one-half miles north of Davis, Calif.

DISTRIBUTION. Known only from type locality.

HABITAT. Salt grass.

NEOPHYLLOBIUS VIRGINIENSIS, new species

Plate 25

FEMALE. Body from above rotund-ovate. Dorsum with very fine striations, mostly tortuous. Fourteen pairs of shortish dorsal body setae, including two pairs on caudal margin, mostly rod-shaped, coarsely serrate or bracteate margined, distributed as follows: The longest pair subfrontally over sides of mandibular plate; 7 submarginal setae each side from coxae I back nearly to caudal setae; 4 along hind margin of body; 4 submedian pairs, the first 3 pairs minute, the last pair longer; mostly shorter than intervals to setae next behind. Rostrum and palpi short (deflexed and not readily observable in specimens). Mandibular plate small, rounded in front. Evidently one eye cornea each side, between second and third submarginal setae. Second segment of palpus largest, bearing a strong, setose seta dorsally, and a similar smaller seta laterally; penultimate segment without a claw (last segment could not be seen properly for study). Legs all longer than body, legs I and IV the longest; leg setae mostly stiff, linear-lanceolate, finely setose, those on legs I and II mostly longer than intervals to nearest setae beyond; tarsi much shorter than tibiae, somewhat swollen at middle; duplex setae evidently lacking; patellae very short, bearing a single noticeable seta about as long as segment, patellae I and II bearing also a barely visible spine; tarsi I and II each with a spindle-shaped sensilla dorsally near base. All tibiae subdistally bearing a very short spine. Onychium bearing 2 stout, simple claws, and between them a pulvillus lined on each side with a pectinate series of tenent hairs. Relative lengths of segments of leg I as follows: Coxa ?; trochanter, 7; femur, 33; patella, 5; tibia, 33; tarsus, 14. Male not known.

TYPE MATERIAL. U. S. Nat. Museum No. 1748.

TYPE LOCALITY. Arlington, Virginia.

DISTRIBUTION. Known only from type locality.

HABITAT. Unknown.

The above description is based on one specimen each on two slides bearing sample number E-7483, collected November, 1938, by Floyd Andre.

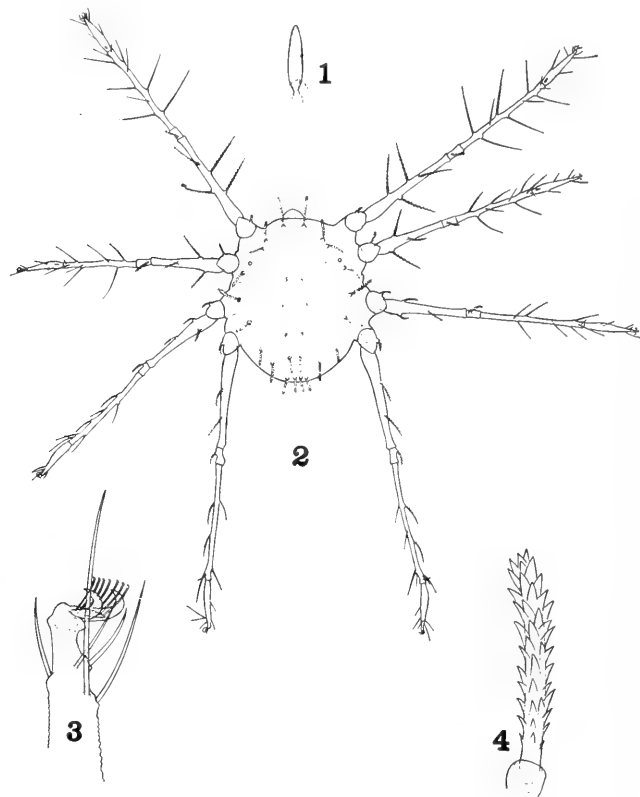


PLATE 25

NEOPHYLLOBIUS VIRGINIENSIS, new species. 1, sensory seta borne on tarsi I and II; 2, female mite, dorsal view; 3, tip of tarsus, lateral view; 4, one of the larger dorsal body setae.

ALLERGIC SENSITIVITY TO THE SALIVA OF THE WESTERN CONE-NOSED BUG

By SHERWIN F. WOOD

Life Sciences Department,
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For some years the writer has been collecting data on man's reaction to the feeding of the western cone-nosed bug and related species of *Triatoma* (Wood 1941a, 1941b, 1942a, 1942b), since some species serve as vectors of Chagas' disease, or American human trypanosomiasis. Those individuals who are sensitive, or become sensitive to the substances in the saliva of *Triatoma*, vary greatly in their responses, but some individuals are made severely ill as is indicated by two recent cases discussed below. Such immediate responses are probably reactions to substances introduced through the bloodsucking feeding habits of the insect.

A good general discussion of cone-nosed bugs in relation to man is recorded by Dodge (1948), who reports observations of Wehrle (1939). Additional reactions of man are discussed by Herms (1939). Wood (1942b) recorded the reaction to the feeding of *Triatoma protracta* of Mr. Fred Reynolds in 1941, who reported in the fall of 1948 as follows: "Last summer I had a bite which caused a condition similar to hives (urticaria or angioneurotic edema)."

Through the courtesy of the Bureau of Vector Control, State Department of Public Health, the writer was able to contact Mr. Robert P. Allen, economic entomologist, who has collected 15 specimens of *Triatoma protracta* from his residence in the foothills of the Sierra Nevada between Oct. 1, 1948, and Aug. 31, 1949. For his experiences with these bugs during the summer of 1949, he reports regarding his 18 months old daughter that she "obviously was bitten on the face by something; a large welt around the bite developed; she was 'fussy and uncomfortable' for a while, but not ill; the swelling subsided and she recovered completely in a few hours. Positive proof of the cause is lacking, but my wife saved for me the bug which she found on the wall above the baby's bed soon after the symptoms were first noted."

However, with regard to a neighbor who brought three specimens of *Triatoma protracta* to him, he reports as follows: "Mr. Z' was bitten four or five times on the back by something about 1:00 A.M., after returning from work at midnight and retiring. Soon afterward Mrs. 'Z' found a *Triatoma protracta* under his pillow. The bites were not at first noticeable. His first reaction

was that he had been poisoned. Starting for the bathroom, he collapsed and lost consciousness completely for a few minutes. He recovered sufficiently to walk, and suffered a period of nausea and diarrhea. Returning to bed, he experienced the following symptoms in rapid succession: severe itching over body and especially on the feet, skin turned red, broke out in a cold sweat, suffered recurring chills, and temperature dropped below normal. He 'felt dead,' and was unable to sleep until about 6:00 A.M. He recovered sufficiently to go to work as usual the next evening, but did not feel well for ten days to two weeks."

"Mr. 'Z' suffered similar symptoms once previously, but had no reason to suspect a bug bite as the cause. Mrs. 'Z' and two teen age daughters report that they all have been bitten, but suffer only local itching and swelling."

Through the kindness of Dr. W. Dwight Pierce of the Los Angeles County Museum, and Mr. Norman Ehmann, entomologist for the Los Angeles City Health Department, the writer interviewed both Mr. "E" and Mrs. "V," and saw specimens of *Triatoma protracta* Uhler collected by them.

Mr. "E," aged 79, was able-bodied and in good health until recently. He has known these insects near Palmdale, California, from their pestiferous feeding habits since 1938. In June of 1949, following the bite of *Triatoma protracta*, Mr. "E" noted intense and annoying itching of the palms of the hands; soles of the feet, and the neck, after which he lapsed into unconsciousness for several hours. The itching was followed by edema of the affected parts and he was extremely weak for some time following this bug's feeding upon him.

Prior to this severe reaction, the effects were delayed 12 or more hours, and nausea and diarrhea were noticeable accompaniments of the discomfort produced by contact with this insect. On two previous occasions, a partial throat paralysis prevented swallowing for some time. Mr. "E"'s physician, Dr. H. H. Snook, adds the following: "The symptoms were relieved by epinephrine 1:1000 administered 3 minims at a dose 15 minutes apart for 4 doses along with 1 grain sodium phenobarbital by hypo to relieve nausea, anxiety and nervousness. Ephedrine-aminophylline tablets were also tried but the action was slow and sometimes lost and had to be repeated. This helped some but was not very satisfactory."

Mrs. "V," from near Reseda, California, noted severe itching of the hands, followed by a general edema of the arms and hands, spreading gradually over the body following a "bite" on the right forearm. The edema was accompanied by intense itching, severe dizziness, and nausea lasting approximately two days. The site of the bite on the upper surface of the arm showed a red pinpoint

puncture surrounded by a white wheal enclosed by a reddish ring. The general edema of the arm spread from this point of contact with the proboscis of *Triatoma protracta*.

Her physician, Dr. W. J. Lakey, reported the following: "This patient was seen early on the morning of Nov. 2, 1949. She was in bed, having arisen only to go to the bathroom when she required support due to severe dizziness and nausea. She complained of itching over the entire body, most marked on face, hands, and thighs. She and her husband stated that there had been an infestation of black bugs about the house. Some were found in the bedding and were full of blood. Examination showed a healthy appearing woman of middle age. Face markedly swollen, temperature 98, pulse 76, regular respiration 18. Eruption on the face, arms, hands, chest and thighs was in patches of varying size, some as large as the palm of the hand, slightly raised with pale borders. Diagnosis of urticaria was made, minimizing the bite idea. This could have been a foreign protein reaction or possibly a specific poison due to sucking insects. Exact hour of the bite was not known. Treatment was hypo of adrenalin 1/1000 solution, three minims. Improvement was almost immediate, itching subsiding markedly and swelling of face also. Benadryl was prescribed for further treatment, two capsules once or twice a day."

It is interesting to the writer that with both Mr. "E" and Mrs. "V" the exact time of feeding was unknown, which emphasizes the lack of physical discomfort from contact, or at the time of contact, with the proboscis of the western cone-nosed bug, a bloodsucking insect. This is well attested to by the previous contacts reported by Wood (1941a, 1942a). Both Mr. "E" and Mrs. "V" were awakened some time AFTER the bug had fed, according to their own reactions to the toxic substances introduced in the saliva, or their specific chemical responses to possibly the foreign proteins of the insect's saliva. Riley and Johannsen (1938) have noted that the bloodsucking habit of feeding is not associated with painful bites.

Neghme (1946) has found the aerosol bomb useful for bringing *Triatoma* out of hiding in houses, but the contained insecticides do not kill these bugs readily. However, Randolph (1946) reports 100 per cent mortality for one species of *Triatoma* in laboratory tests with 5 per cent DDT emulsion. Dias and Pellegrino (1948) obtained good kills of *Triatoma infestans* with gammexane P 530, whereas Neghme and Román (1948) report no better results with gammexane than DDT.

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CONTRIBUTIONS FROM LOS ANGELES COUNTY
MUSEUM—CHANNEL ISLANDS BIOLOGICAL
SURVEY

No. 34. SOME OBSERVATIONS ON THE LAND SNAILS
OF SAN CLEMENTE ISLAND

By GEORGE P. KANAKOFF

The material on which these observations are based was collected by the writer during two expeditions made by the Los Angeles Museum Channel Islands Biological Survey, and is compiled from notes made at that time.

The first of these two trips was Expedition No. 5, when the Museum party camped at Smugglers' Point in Pyramid Cove, at the southeast end of San Clemente Island, from November 8 to December 10, 1939. The second trip was Expedition No. 12, when the Museum party camped at Horse Beach Cove near China Point at the southwest of the island, from February 14 to 22, 1941.

As conditions permitted, collecting was done within a ten-mile radius of each camp, and additional collecting was done in the central parts of the island in the vicinity of Middle Ranch, and more to the north at the "Emergency Landing Field," and finally at the northern part of the island in the vicinity of the Naval Training Base at Wilson's Cove, during short intervals, while preparing to land or embark from the island.

As the invertebrate zoologist of the party, the writer, among other material, collected the following species of the land snails:

LIVING:

ENDEMIC

<i>Micrarionta intercosa</i> (W. G. Binney).....	1535	specimens
<i>Micrarionta redimita</i> (W. G. Binney).....	465	"
<i>Micrarionta redimita f. hybrida</i> (Hemphill).....	31	"
<i>Micrarionta gabbi</i> (Newcomb).....	226	"
<i>Micrarionta gabbi f. maxima</i> (Pilsbry).....	73	"
<i>Sterkia clementina</i> (Sterki).....	6	"

NONENDEMIC SPECIES

<i>Succinea awara</i> (Say).....	120	"
<i>Vertigo californica longa</i> (Pilsbry)	71	"

FOSSIL:

<i>Micrarionta intercosa</i> (W. G. Binney)	80	"
<i>Micrarionta redimita</i> (W. G. Binney)	260	"
<i>Micrarionta redimita f. hybrida</i> (Hemphill)	180	"
<i>Micrarionta redimita f. inconstans</i> (Hemphill) ..	12	"
<i>Micrarionta gabbi f. maxima</i> (Pilsbry)	69	"
<i>Micrarionta</i> sp. nov. hereinafter described.....	120	"

Altogether the source material consists of 69 lots from 31 localities. This paper is concerned with observations on *Micrarionta intercosa*, *Micrarionta redimita*, their numerous described "forms" and "varieties," together with the description of a new species of the same genus from a fossil deposit, which the writer believes to be an ancestor of the above named species and of their variations.

In examining various lots of this genus, it is easy to tell at a glance whether they are from the northwestern, central or south-eastern portion of the island. The climatic conditions and rainfall are in striking contrast; the northwestern part of the island from the Isthmus to Mosquito Cove in a long narrow triangular strip has comparatively abundant vegetation and more rainfall, and is for many days of the year under a blanket of fog, whereas the southwestern larger triangular portion of the island is almost bare of vegetation and arid, the middle ribbonlike strip in between partakes of the climatic characteristic of both. At the larger, southwestern portion of the island a few shrubs, cacti, and a few grasses are found only in the deep canyons and gulleys, the top

San Clemente Island

Legend

- | | |
|------------------------|------------------------|
| 1. Northwest Harbor | 11. Horse Beach Cove |
| 2. Wilson's Cove | 12. Smugglers' Cove |
| 3. Landing Field | 13. Horse Beach Canyon |
| 4. Middle Ranch | 14. Smugglers' Canyon |
| 5. Middle Ranch Canyon | 15. Windmill Gulch |
| 6. Cave Canyon | 16. Pyramid Cove |
| 7. Red Canyon | 17. Pyramid Head |
| 8. China Canyon | 18. Mosquito Cove |
| 9. China Point | 19. Horse Canyon |
| 10. Zlich Island | 20. Big Dam Canyon |
| | 21. Chinetti Cove |

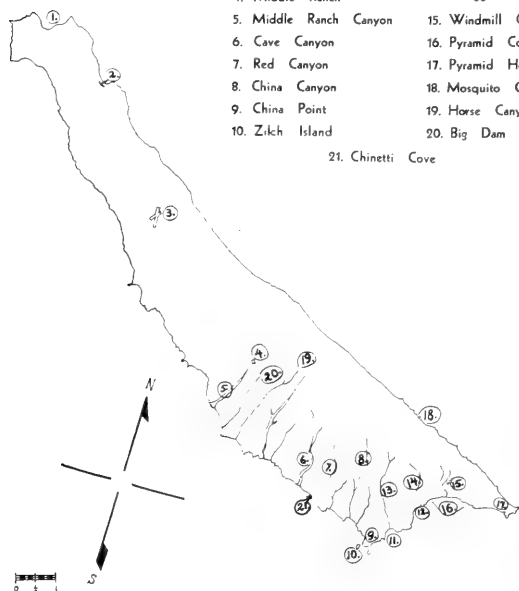


PLATE 26

of the island main plateaux being mostly bare, and in the extreme south end subject to a continuous denudation and sand-blasting. The masses of Miocene sandstones and breccia towering above the canyons here and there are concealed in their lower portion by a light-gray blanket of volcanic tuff from 5 to 50 feet deep. These cliffs, above, where they catch some moisture from the night fog are covered in spots with mosses and lichens, and in the crevices harbor the largest colonies of *M. redimita* and *M. intercisa*. The northeastern lots of these two species have most of the specimens of larger, wider dimensions, with thinner walls and of a brighter color. The southwestern specimens, on the other hand, show a greater variation, having a higher spire, being half as large in diameter, are of bleached appearance, with thick walls and calluses. But one finds a few southern forms in the northern lots, although the northern large forms do not occur elsewhere on the island.

Having at his disposal a particularly long series of *M. intercisa*, the writer experimentally separated this material into groups to match the previously described "forms" and "varieties" of that species in order to illustrate and biometrically to evaluate their validity, with the following results:

Micrarionta intercisa ss

300 specimens were selected from three localities ranging from Airfield to Pyramid Peak—all like the holotype. (W. G. Binney, 1857.)

Micrarionta intercisa form *albida*

"Uniform milk-white, sometimes with a faint band at the periphery; sculpture nearly obsolete . . ." (Hemphill, 1891.)

34 specimens were selected from six sources coming from Middle Ranch Canyon and five southern localities.

Micrarionta intercisa form *callojunctis*

A fossil form:

"Peristome thickened strongly, continuous in a raised ledge across the parietal wall." (Pilsbry, 1939.)

The writer failed to match perfectly more than one specimen (No. 27, Lot 464-39) with the holotype kindly sent by Dr. H. A. Pilsbry (ANSP No. 10806) and was unable to draw any line between this and many apparently intergrading specimens from this fossil lot.

Micrarionta intercisa form *crebristriata*

" . . . peristome narrowly expanded, thinner than in *M. intercisa* proper, having but little thickening within, the columella con-

cave or slightly straightened, not toothed. Umbilicus nearly covered." (Newcomb, 1864.)

214 specimens were selected from two sources ranging from Northwest Harbor to Middle Ranch Canyon. This is the largest *geographical race* of the species. In the Middle Ranch Canyon lots it begins to intergrade with the southern forms.

"Micrarionta intercosa form ductor"

A fossil form:

"Lip and parietal callus moderately thick, the latter adnate; size large, 25.5 by 29.0 mm., $5\frac{1}{2}$ whorls." (Hemphill in Pilsbry, 1939.)

After a careful examination of the two specimens sent by Dr. H. A. Pilsbry (ANSP No. 86748) the author is convinced that this is a case of misnomer or a typographical error. The two specimens closely matching our specimens (No. 1, Lot 464-39, and No. 22, Lot 528-39) are undoubtedly a form of *M. redimita* (W. G. Binney): Our specimens are extremely close to *M. redimita* form *hybrida*. Hemphill in Pilsbry, 1939.

It is interesting to mention here that a remnant of a deposit, very much resembling Upper Pleistocene (Palos Verdes Sand) was found on the little island 350 yards to west of southwest off of China Point, marked on some maps as Zilch Island. In nine pounds of screenings, consisting of a marine shell deposit, several land snails were found, larger than but very closely fitting this form. (Op. Cit. figs. "h" and "i.")

Micrarionta intercosa var. *elegans*

"Uniform ashy-buff color, faintly banded and variable in form." (Hemphill, 1891.)

75 specimens were selected to match this color form ("Pale Congo Pink" by Ridgeway) from four sources ranging from Wilson's Cove to China Point. It was the author's observation that where there was less protection from light (on rocks) this color form predominated and the specimens collected under thick layers of cacti (*Opuntia littoralis*) had more color the deeper they were buried.

Micrarionta intercosa var. *minor*

"Smallest specimen, greatest diameter 18 mm., altitude, 11 mm. uniform light-yellowish chestnut color, with and without a band and varies very much in form and elevation or depression of spire." (Hemphill, 1891.)

This is a typical stunted form of the species so abundant in the southern portion of the island. 160 specimens were selected from Windmill Gulch.

Micrarionta intercosa var. *nepos*

"... uniform ashen-white; spire horn color, variable in form and sculpturing..." (Hemphill, 1891.)

The first two to four whorls in color match "Pale Vinaceous-Fawn," and "horn" (of Hemphill) matches "Russell-Vinaceous," both of Ridgeway.

140 specimens were selected from two sources of the southern portion of the island.

Micrarionta intercosa form *puer*

A fossil form:

"Small, diameter 15 to 20 mm., often angular at periphery." (Hemphill in Pilsbry, 1939.)

123 specimens were selected from three sources of southernmost localities of the island. After examining long series of this form and living var. *minor*, the author is convinced that this fossil form is an ancestor of the living var., as they are found to intergrade structurally.

In the course of Expedition No. 5, during December, 1939, while on the southern slope of the small volcanic hill at the southwestern end of China Point, the author secured a lot of 28 shells unearthed by the rapid denudation. Intrigued by their large size and curious about the source of these shells, which were scattered on the west-southwestern portion of the slope, the writer, on December 6, undertook an excavation, and in a trench on the side of the slope made from the top downward, uncovered, after a day of digging, a stratum of a dark-gray coarse sand with over 700 shells of land snails imbedded in it. This stratum was from 2 to 3 inches in thickness and about 9 feet long. It was perfectly horizontal and was imbedded at half way up the hill, exactly 250 feet above sea level. The dark-gray stratum was in striking contrast with the light whitish-gray color of the fine volcanic tuff of the matrix of which the whole hillock was built; both the stratum and the matrix were strewn and imbedded throughout with two kinds of rocks, namely, shaly with sharp edges and triangular-rounded. The first assumption that this stratum represented Lower Pleistocene (Lomita Marl Formation) had to be abandoned because no confirming factors could be found. It could be a land laid stratum of the same epoch. According to Lawson, Cooper and Smith* it could be some "Post Pliocene" deposit only. Judging by the traces of color on some of the specimens, the writer believes that it belongs to Upper Pleistocene or later time. Each time the wind blew, the hillock was sand-blasted and the impression given was that it was melting away from day to day.

The lot (A. 4616-464-39) collected there was composed of over

700 specimens, containing 120 specimens of a different species from anything else found on the island.

Dr. H. A. Pilsbry, quoting Holder, 1910*, mentions fossil forms of *M. intercisa* and those of *M. redimita* as an "abundant fossil of the sand dunes." These same statements were made by earlier writers, unfortunately none of them indicating any fossil localities.

The sand dunes of most of the Channel Islands and especially of San Miguel, San Nicolas, Santa Catalina and San Clemente are thickly covered with dead, bleached and sandblasted shells of both land and marine snails and marine clams. The writer has observed that one of the main sources of this debris is the abundant kitchen midden material, removed from mounds by a continuous process of denudation.

However, the secured lot of fossil (or subfossil?) extinct shells excavated from the stratum mentioned above (disregarding the similar material found loose in the vicinity) is a uniform species and distinct from all the species, "forms" and "varieties" described previously from the island. It is the writer's conviction that this



PLATE 27

species is an important link with the past in the chain and is the direct ancestor of *M. intercosa* and *M. redimita* with all their variations. Therefore it is being hereby placed on record as:

MICRARIONTA (XERARIONTA) AGNESÆ sp. nov.

(Plate 27)

DESCRIPTION:

Shell large for the genus, grayish-white, whorls 5, depressed-globose, bicolored; the two embryonic whorls smooth, later gradually become obliquely striated; after the third whorl striation becomes coarser and reaching the body whorl it becomes fine axial malleation, crossed at 35 degrees by the lines of growth; the outer lip faintly toothed or smooth, wide, oval, thick and descending in front; body whorl with a slight trace of a darker color on the upper third of it; sutures rather deep and wavy; the spire but slightly elevated; the second nuclear whorl being the highest; umbilicus wide, partly covered by moderately thick peristome, which is slightly expanded; parietal callus thin or wanting. Greater diameter 32.27, lesser diameter 25.32; greater altitude 21, lesser altitude 15.5; lip length 16.5, lip width 14.5 mm.

The holotype No. 1088 is in Los Angeles County Museum, Division of Invertebrate Paleontology.

This shell is named *Micrarionta agnesæ* in honor of Mrs. Agnes C. Boynton, in token of the deep respect and admiration of the author for her lifelong and untiring love for natural history.

DISCUSSION:

The large size and comparative thinness of this shell suggest a moist climate and abundance of food similar to conditions at the northernmost end of the island at the present time. In these characters and in sculpture it resembles the northern larger form of *M. intercosa* (form *crebristriata*); by its depressed shape it resembles *M. redimita* and is in striking contrast with the existing stunted, high-spined forms of this species which are found in abundance in the southwestern part of the island. In general appearance (except for size) *M. agnesæ* strongly resembles *M. indiænsis xerophila* Berry, but its large size makes it impossible to mistake it for any other species.

This discussion is based on a lot of 120 perfect or nearly perfect specimens collected in the China Point deposit in situ. The typical small race of *M. intercosa* collected at 12 localities between China Point and Pyramid Head exhibits the following measurements:

(Absolute Mean, based on 400 specimens)

Greater diameter	22.2 mm.
Lesser diameter	18.8 mm.
Height	16.7 mm.
Lip length	9.2 mm.
Lip width	9.5 mm.

The northern race of this species measures:

(M. intercesa form crebristriata)

Greater diameter	from 19 to 26 mm.
Lesser diameter	from 17 to 22 mm.
Height	from 16 to 20.5 mm.

BIOMETRIC STUDY

All specimens from the island were counted, numbered and measured. Experimentally the following measurements were used:

1. Greater diameter
2. Lesser diameter
3. Lesser altitude

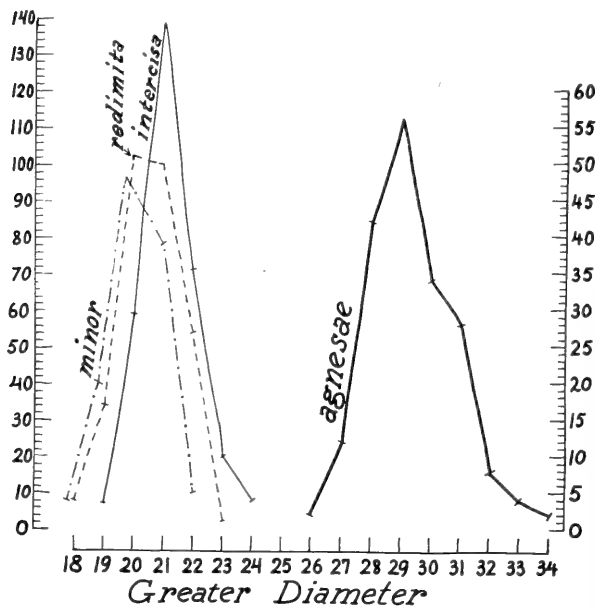


PLATE 28

4. Length of aperture
5. Lesser width of aperture
6. Greater width of aperture
7. Greater altitude

and following ratios were calculated:

8. Ratio 1:7
9. Ratio 4:6
10. Ratio 2:3

The accompanying plates, 28 to 31, show some measurements and the curves resulting from the measurements and their ratios. The many curves were set experimentally and have proved to be unexpectedly interesting, although some of them appear to have more significance than others.

It appears from the curves made on all measurements and ratios of *M. intercosa* and all of its "forms" and "varieties" that they overlap each other to such an extent that reproduction of such a

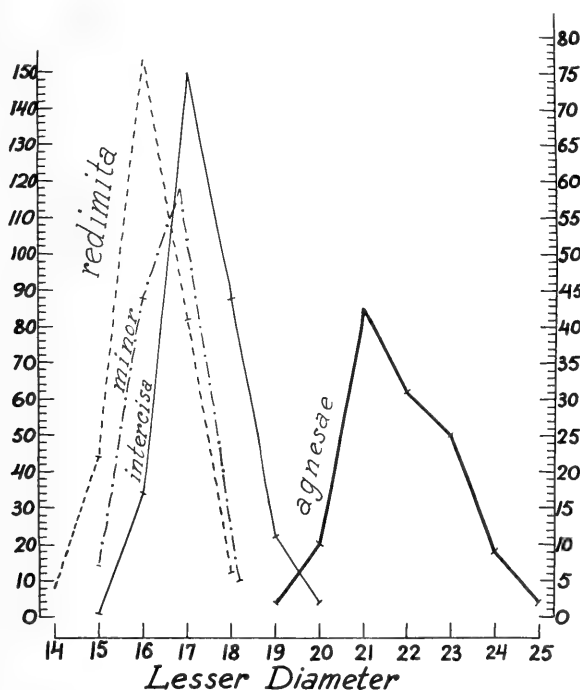


PLATE 29

diagram would look confusing and incomprehensible. It has, however, one exception in the variety *minor* in living and the form *puer* in fossil material. These two have a curve of their own different from the rest. As it is the writer's conviction that the former is a direct descendant of the latter, the sets of curves selected for this paper include var. *minor* in comparison with *M. intercisa*, *M. redimita* and their ancestor, *M. agnesæ*.

The writer refrains from premature conclusions of the significance of such biometric curves, but merely points out that the shape of the curve in Ratio 1:7 (greater diameter to greater altitude) repeats also in the curves of the other measurements for each species. *M. agnesæ*, for instance, has constantly a "hip" on the right side of the curve; *M. intercisa* and its var. *minor* (which in the author's opinion rates a subspecific status) repeat a pyramidal-shaped curve, and, finally, *M. redimita* repeats a blunt-spired curve.

Whenever opportunity offers a sufficiently long series, the writer feels that many conclusions that are biased by personal opinion or faulty interpretation can be eliminated, improved or corrected by systematic accumulation of this kind of statistical material.

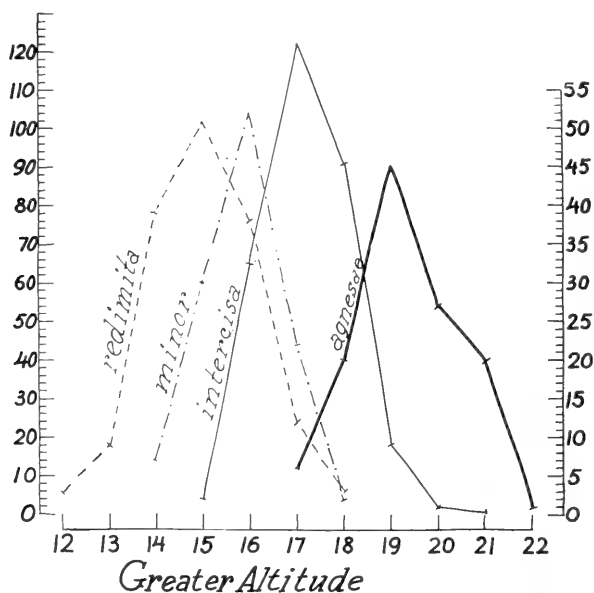


PLATE 30

*LITERATURE

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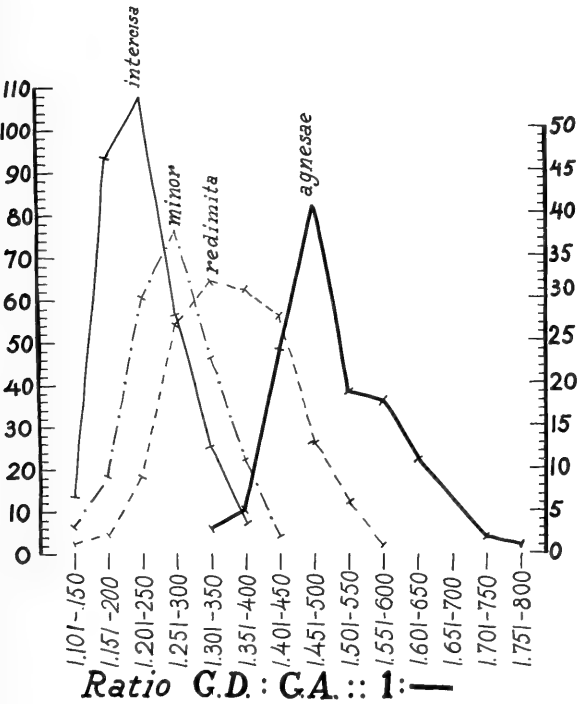


PLATE 31

THE OCCURRENCE OF *CHELURA TEREBRANS* PHILIPPI IN LOS ANGELES AND SAN FRANCISCO HARBORS

By J. LAURENS BARNARD*

Specimens of the amphipod *Cheulra terebrans* Philippi, from Los Angeles and San Francisco harbors, have been made available to the writer through the courtesy of Mr. Robert J. Menzies, Mr. Carrol Wakeman, testing engineer, Los Angeles Harbor Department, and the Southern California Marine Borer Council.

Cheulra, to the writer's knowledge, has not been reported in the literature from the Pacific Coast of North America. In the "Report on the San Francisco Bay Marine Piling Survey," 1921, p. 57, Kofoed stated that "*Cheulra* has not been found by us in the survey of San Francisco Bay nor in piling from Monterey, Santa Barbara, or Gaviota." The materials available show that this genus is now very abundant both in San Francisco and Los Angeles harbors occupying burrows in wooden marine pilings and associated with *Limnoria quadripunctata* Holthuis (1949), a wood-boring isopod.

The living animals may be distinguished easily from *Limnoria* by their pinkish color. Preserved specimens may be recognized with the aid of a hand lens, by the large dorsal spine on the third abdominal segment and the elongated third uropods or last pair of appendages.

Material from the Atlantic Coast, used for comparative purposes, was kindly donated by the William F. Clapp Laboratories of Duxbury, Mass. The following pages contain a description and figures of the species, based on material from the Pacific Coast, deposited in the collections of the Allan Hancock Foundation.

The writer is indebted to Capt. Allan Hancock, Director of the Foundation, for the use of laboratory and equipment.

Order Amphipoda
Gammaridea

Family CHELURIDAE Allman, 1847
Genus *Cheulra* Philippi

Cheulra Philippi (1839), pp. 120-121.

GENOTYPE—*Cheulra terebrans* Philippi (1839).
Cheulra terebrans Philippi
(Plates 32 and 33)

*Contribution from The Allan Hancock Foundation, The University of Southern California

Chelura terebrans Philippi (1839), pp. 120-121, pl. 3, fig. 5; Allman (1847), pp. 361-368, pls. 13, 14; Smith (1879), pp. 232-234, fig. 1; Della Valle (1893), pp. 347-350, pl. 6, fig. 3, pl. 7, figs. 1-22 (with synonymy); Sars (1895), pp. 627-628, pl. 225; Holmes (1905), pp. 508-509, 1 fig.; Stebbing (1906), pp. 693-694, fig. 119; Kunkel (1910), pp. 103-105, fig. 40; Stebbing (1910), pp. 463-464; Chevreux (1911), p. 272; Chevreux and Fage (1925), pp. 371-373, figs. 379, 380; Schellenberg (1928), pp. 673-674; Sheard (1937), p. 28; Pirlot (1938), p. 354; Schellenberg (1942), pp. 229-230, fig. 188.

Limnoria xylophaga Hesse (1868), pp. 101-109, pl. 9.

Description of male.—Head about the length of the first two peraeon segments combined, forward prominence of head evenly rounded from lateral view, appearing rounded from above and behind, but subacute from above and in front. Lateral lobes of head rather evenly rounded, inferolateral corners well defined. Eyes well developed, asymmetrical in outline.

Antenna 1 reaching beyond fourth article of antenna 2, articles of peduncle successively shorter, flagellum composed of four or five articles, equal in length to last two articles of peduncle combined. Accessory flagellum uniarticulate, slender, about the same length as or longer than the first article of primary flagellum.

Antenna 2 stout, strongly setose, last three articles successively slightly longer, flagellum spatulate, slightly longer than last article of peduncle, consisting of one large article with one or two minute, indistinct, button-like articles at its distal end.

Mandible: molar well developed, transversely ridged, cutting plate with four or five teeth, accessory plate present in right mandible only, shorter than primary plate, spine row with four or five echinulated spines. Palp stout, third article shorter than second, inner apex armed with two long setae and lined on the inner margin with short setae.

Lower lip: mandibular processes well developed, ends rounded, apices of major lobes truncate, hairy. Inner lobes faintly defined.

Maxilla 1: inner plate one-half as long as outer plate, apex rounded, tipped with three long, plumose setae. Outer plate armed with eight or nine serrate spines. Palp, second article more than twice as long as first article, apex of palp of right maxilla armed with eight small spines, of left maxilla armed with four large tooth-like spines.

Maxilla 2: outer plate slightly longer and more slender than inner plate, apical margins setose.

Maxilliped: inner and outer plates of about the same length, apex of inner plate subacute or slightly rounded, inner and apical margins setose. Apex of outer plate subacute, setose, not reaching to middle of article 2 of palp. Article 3 of palp, distal end with a lobe covering part of article 4. Article 4 short, tipped with a spine.

Gnathopod 1: article 2 stout, subrectangular, posterior margin armed with two finely ciliated setae. Article 5 about as long as articles 3 and 4 combined, its posterior margin armed with pectinate setae. Article 6 subrectangular, half again as long as article 5, its inferoposterior angle produced slightly to form a thumb-like process against which the seventh article closes. Anteromedial surface of article 6 with two transverse rows of strongly pectinate setae; posterior edge also armed with pectinate setae. Tip of article 7 closing between two small spines.

Gnathopod 2 similar to gnathopod 1 but slightly longer and more slender. The posterior margin of article 5 is unarmed except for the distal portion which has several setae and a row of curved, pectinate spines. Anterior margin of article 5 bearing plumose setae. Articles 5 and 6 subequal in length. Article 6 lacking pectinate setae but armed with plumose setae.

Peraeopod 1: article 2 long, stout, articles 3 and 5 subequal in length, articles 4 and 6 also subequal in length. Inferoanterior angles of articles 4 and 5 produced, article 6 more slender than article 5, armed with three spines on posterior margin. Article 7 strong, claw-like.

Peraeopod 2 similar to peraeopod 1 but smaller and with only two spines on posterior margin of article 6.

Peraeopods 3-5 successively slightly longer. Peraeopod 5, second article stout, long, articles 3 and 5 subequal in length, article 6 longer than article 4, tapering to distal end, bearing a longitudinal row of three to seven spines and three spines at distal end. Article 7 similar to that of peraeopod 1 but inclined outwards, Article 4, distal anterior and posterior margins produced and each beset with a spine. The posterior margins of articles 2, 4, and 5 are armed with long, plumose setae.

Peraeopod 3 slender, similar to peraeopod 2 in size, article 6 with three longitudinally placed spines, and two spines at distal end near the insertion of article 7. Plumose setae scarcely developed.

Peraeopod 4 slightly longer and stronger than peraeopod 3, article 6 with five spines in longitudinal row, plumose setae well developed on posterior margin of article 2.

Pleon segments 4-6 fused dorsally, marked ventrally with intersegmental grooves, segments 4 and 5 short, segment 6 greatly elongated. Dorsal surface of pleon segment 3 produced into a long, arched, blunt spine, reaching more than half-way back above fused segments. Beneath this spine, the segment is produced into a short shelf which projects back horizontally. Posterolateral corners of pleon segment 3 each produced into a strong, sharp tubercle. Dorsal surface of fused segments with two very low,

lateral elevations, fused along their midlines in the anterior one-third, but split apart posteriorly to form two mounds, the posterior margins of which are broadly rounded and each margin supplied with two to four small, sharp tubercles, two of which may be fused together by a ridge. About midway back on the elevations are two other laterally placed tubercles. Anterior to the telson are two large, blunt, laterally situated tubercles or bosses and anterior to these are two smaller ones which almost form a bridge across the depression between the large, lateral mounds. The fused pleon segments in young males are less than half as long as the rest of the pleon and peraeon combined, in older males (5 mm) they are more than half as long.

Uropods 1 and 2 attached to a lateral plate formed of fused outgrowths of pleon segments 4 and 5.

Uropod 1 reaching almost to end of pleon in young males, reaching about three-fourths of the way in large males. Peduncle slightly more than twice as long as rami, its inferior and superior margins lined with setae. Outer ramus slender, setose, of about the same length as inner ramus in young males, longer in adult males, but projecting slightly farther because of its insertion on a slight process of the peduncle. Inner ramus broad, apex roughly truncate, armed with three or four spines.

Uropod 2 inserted directly above uropod 1, outer edge of peduncle expanded into a large, elongated, setose, crenulated plate. Rami small, outer ramus much larger than inner in large males, nearly subequal in younger specimens; apices roughly truncate, crenulated, setose.

Uropod 3: peduncle short, inner ramus small, ovate, nearly covered by telson, outer ramus large, long, margins irregularly crenulated, outer margin armed with fascicles of setae and an occasional spine, inner margin with spines and a few setae. Dorsal surface slightly setose.

Telson foliate, apex pointed, inferior surface produced into a longitudinal keel.

Dorsal surface of peraeon and first two segments of pleon with setae arising along the posterior edge of each segment.

Description of female.—Differing from the male by the following points: (1) the dorsal spine of pleon segment 3 is shorter, not arched; (2) the plate of the peduncle of uropod 2 is subquadrate in outline and the rami are much shorter and broader; (3) the rami of uropod 3 are shorter and slightly broader; (4) both peduncle and rami of uropod 1 are stouter than in the male, and like young males the uropod extends nearly to the end of the pleon.

Material examined.—Sausalito, San Francisco Bay, Marin Co., Calif., April 28, 1949, 50 specimens, coll. R. J. Menzies; Tiburon,

Northwestern Pacific Railway Ferry, San Francisco Bay, April 30, 1949, 28 specimens, coll. R. J. Menzies; Cabrillo Beach, San Pedro Harbor, Los Angeles Co., Calif., several hundred specimens, coll. J. L. Barnard.

In addition to the above localities the writer examined specimens from the following localities through the courtesy of the William F. Clapp Laboratories: Cuttyhunk, Boston, Quincy, Woods Hole, Weymouth, all in Massachusetts; Newport, R. I.; New London, Conn.; San Francisco, Calif.

Remarks.—Subsequent reviewers have overlooked the ornamentation of the pleon, although Philippi (1839) in the original description of this species noted the presence of small tubercles on the dorsal surface of the pleon; Allman (1847) figured the lateral mounds on the last segments of the pleon; Hesse (1868) described a crease down the middle of the pleon; and Smith (1879) figured two tubercles anterior to the telson.

The small tubercles (actually on pleon segment 6) are not always clearly defined and may be covered with debris. There is considerable variation exhibited in the number and placement of the tubercles in members of both sexes. Some of these variations are illustrated in the diagrams on plate 32.

This species is widely distributed in both Atlantic and Mediterranean waters, and is recorded from South Africa, Australia, and New Zealand.

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EXPLANATION OF PLATES

PLATE 32

Chelura terebrans Philippi

FIGS. 1-5, male, 4.25 mm. long, Sausalito, Calif.

FIG. 1. Dorsal view, not showing dorsal segmental setae, scale, 1 mm.

FIG. 2. Maxilliped.

FIG. 3. Mandible, right.

FIG. 4. Palp of maxilla 1, left.

FIG. 5. Maxilla 1, right.

FIGS. 6-10, diagrams showing variations in tubercles of
pleon segment 6, material from Sausalito, Calif.

FIG. 6. Male, 3 mm.

FIG. 7. Male, 5 mm.

FIG. 8. Male, 4 mm.

FIG. 9. Male, 4.5 mm.

FIG. 10. Male, 3 mm.

PLATE 33

Chelura terebrans Philippi

FIG. 1. Lateral view of head of male, 4.25 mm. long, Sausalito, Calif.

FIG. 2. Uropod 1, left, female, 3.5 mm. long, Sausalito, Calif.

FIG. 3. Peraeopod 5, right, male.

- FIG. 4. Uropod 3, left, female.
 FIG. 5. Gnathopod 1, right, male.
 FIG. 6. Gnathopod 2, right, male.
 FIG. 7. Peraeopod 1, right, male.
 FIG. 8. Uropod 2, left, female, ventral surface.
 FIG. 9. Uropod 1, right, male.

Magnification: scale A, 1 mm. for figs. 1, 3, 5, 6, 7.
 scale B, $\frac{1}{2}$ mm. for figs. 2, 4, 8, 9.

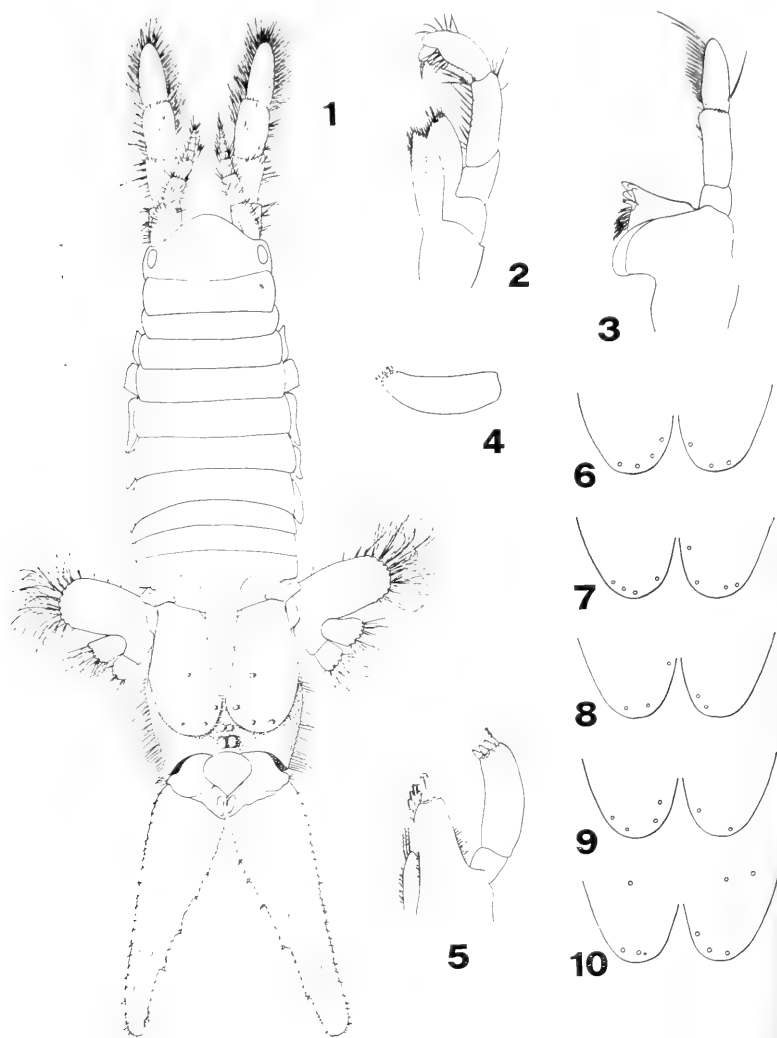


PLATE 32

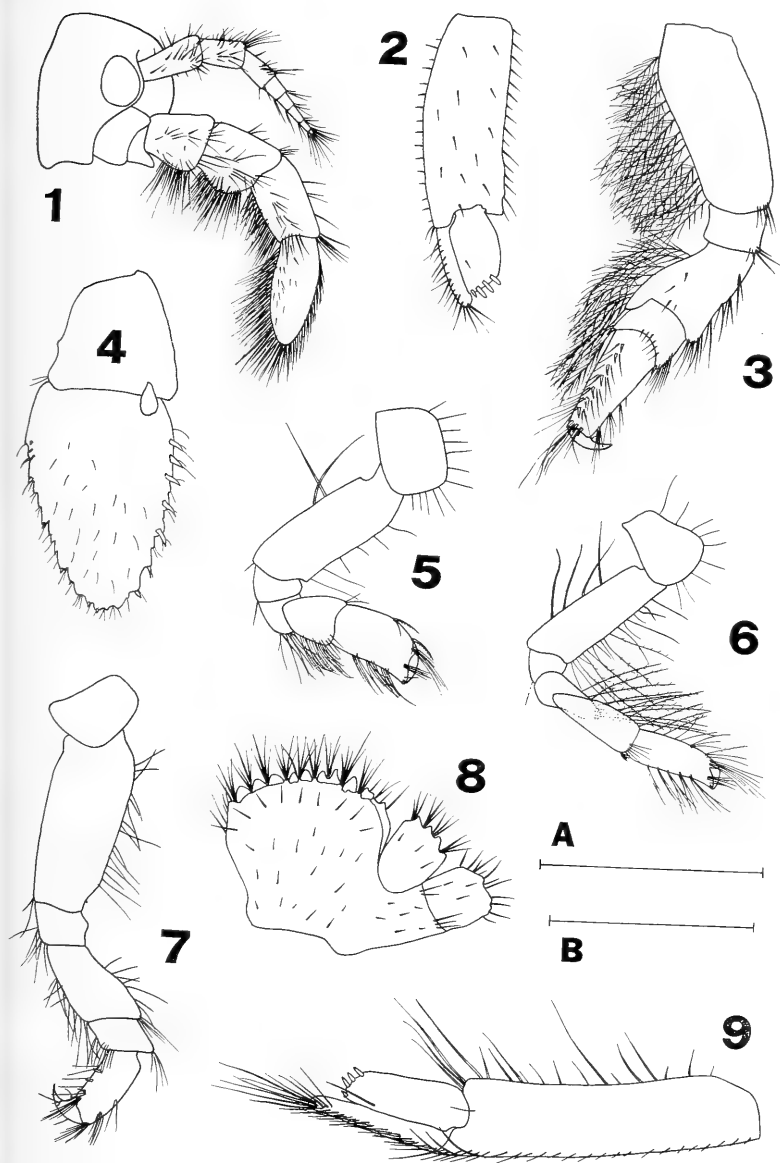


PLATE 33

THE DISTRIBUTION OF CALIFORNIA INSECT VECTORS HARBORING *TRYPANOSOMA* *CRUZI* CHAGAS

By SHERWIN F. WOOD

Life Sciences Department, Los Angeles City College, Los Angeles 27, Calif.

The causative agent of Chagas' disease or American human trypanosomiasis, *Trypanosoma cruzi*, is apparently widespread throughout California wherever the western cone-nosed bug, *Triatoma protracta*, is found. Because of greater annoyance to man by these bugs in recent years (Wood, 1950), more specimens have been examined in scientific laboratories. This has made possible the recording of several additional localities for infected bugs since publication of the summary by the writer (Wood, 1942), as shown in Table 1.

The Murray Canyon locality is unique in the accessibility, concentration and size of wood rat houses, the abundance of insects, and the consistent occurrence of naturally infected *Triatoma*. In the spring of 1935, Whitaker (1937) collected 500 adults and nymphs of *Triatoma protracta* from this region which boosts the total to 1,181 specimens known from this one area. The writer collected a record number of 85 specimens from one wood rat house in this canyon.

In the Eaton Canyon area near Pasadena, eight wood rat houses were diligently searched in December of 1948 without finding a single *Triatoma*. Possibly the heavy collecting of previous years, as shown in Table 1, plus variable adverse climatic factors has reduced this population although the bugs may have retreated to underground burrows as they do in summer months in parts of Arizona, New Mexico, and Texas.

The verification of Davis's (1943) record for Plymouth plus the new records from LaGrange, O'Neals, Three Rivers, and Tazana indicate a continuous pattern of distribution from the southern coast inland through the great central valley of California.

Through the kind co-operation of Mr. Fred Reynolds near Trimmer Springs, specimens of *Triatoma protracta* were received as follows: 1 in '40, 21 in '41, 19 in '46, and 24 in '47, as shown in Table 1. He reports two seen in his canyon home during the summer of 1948 and one in a neighbor's house, whereas only three specimens were observed in the summer of 1949.

From records supplied me by the Bureau of Vector Control, State Department of Health, and Robert P. Allen, Economic Ento-

TABLE 1
California Localities for *Trypanosoma cruzi* in
Triatoma protracta (Uhler)

Locality	No. of Bugs Collected	No. of Bugs Examined	No. of Bugs Infected	Per Cent Infection	Reference and Years Sampled
Murray Canyon, San Diego Co.	681	453	137	30.2	F. D. Wood (1934) 1932, 1933, 1937, 1939
Eaton Canyon, Los Angeles Co.	177	170	62	36.4	S. F. Wood (1938) 1936, 1937, 1939, 1946
Trimmer Springs, Fresno Co.	65	46	13	28.2	S. F. Wood (1942) 1940, 1941, 1946, 1947
Griffith Park, Los Angeles Co.	20	20	6	30.0	S. F. Wood (1942) 1941, 1942, 1946, 1950
Plymouth, Amador Co.	5	5	5	100.0	Davis (1943) 1946, 1948, 1949
Fallbrook, San Diego Co.	316	311	94	30.2	S. F. Wood (1944)
Three Rivers, Tulare Co.	1	1	1	100.0	1947
O'Neals, Madera Co.	25	25	17	68.0	S. F. Wood (1942) 1941, 1949
La Grange, Stanislaus Co.	6	6	1	16.6	1949
Tarzana, Los Angeles Co.	18	18	2	11.1	1950
TOTALS	1314	1055	338	32.0	

mologist, 12 *Triatoma protracta* were collected near LaGrange, in addition to the specimens reported in Table 1. Four came from a lumber pile near a house in the fall of 1948, and eight came from a residence in the fall of 1948, and spring and summer of 1949.

Although the LaGrange, Plymouth, O'Neals, Three Rivers, and Tarzana sources have not been studied in mammals, the morphological similarity of all parasites to other nearby sources of *Trypanosoma cruzi* indicates their probable common identity.

The exact locations for Plymouth, Trimmer, Three Rivers, and Fallbrook specimens are: 7 miles east of Plymouth, 3 or 4 miles northwest of Trimmer Springs, 2 miles southwest of Three Rivers (near "Slick Rock"), and 5 miles southwest of Fallbrook.

Most of the bugs collected by the writer have been obtained in brush pile houses of the wood rat (*Neotoma* spp.). The average number of bugs found in 419 California wood rat houses was 2.6 as compared with 2.8 for 723 wood rat houses (including California) searched throughout southwestern United States.

To June, 1950, the writer has collected or received 1,571 *Triatoma protracta*, 31 *Paratriatoma hirsuta*, and 1 *Triatoma rubida uhleri* from California. Of 1,297 *Triatoma protracta* examined, 338 or 26% were found naturally infected with *Trypanosoma cruzi* as compared with 32% for all bugs examined from the infected localities alone, as shown in Table 1. From the southwestern United States, 358 or 23.4% of 1,524 *Triatoma protracta* examined were infected. Of 144 *Triatoma protracta* collected from human habitations in southwestern United States, mostly California, 115 were examined and 40 or 34.7% were found naturally infected.

Thus, there are at least 10 localities for recovery of *Triatoma protracta* naturally infected with *Trypanosoma cruzi* in California.

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FOSSIL ARTHROPODS FROM ONYX MARBLE

By W. DWIGHT PIERCE

1. INTRODUCTORY NOTE.

In the search for fossil insects we have perhaps been overlooking what may be a fertile field—the hot springs of our western country.

References in paleontological literature are very scarce. In 1928 Otto Schmidtgen (*Verhandl. Zool-Bot. Ges. Wien* 78(1): (35)-(39) reported on the trails of 20 kinds of insects from what was probably the border of a pool in Permian deposits at Nierstein on the Rhine.

In 1929 Friedrich Zeuner (*Palæontol. Zeitsch.* 11(4):330-339, 1.pl.) described a rich Miocene thermal spring lime deposit containing many kinds of insects. He concluded that the animals overcome by the fumes, dropped into the spring, became asphyxiated, and were encased with lime within a few hours, before organic decay set in. Thus a perfect preservation of form occurred, second only to amber inclusion.

In the *Desert Magazine* of August 1946, John Hilton, artist and desert naturalist, wrote an article "Fossils while you wait," describing a high pressure flow of hot water highly charged with aragonite, forming onyx of various colors.

This water is so mineralized that insects, plants and animals falling in it are quickly covered with fine crystals and preserved. This well is near the Canal Road between the Chocolate Mountains and the Salton Sea, 29.3 miles from Mecca, California, in the Imperial Valley.

There are many onyx forming hot springs, especially in the neighborhood of the San Andreas Fault, and these must be studied to learn the steps in fossilization, and to find true fossil material.

Dr. Alexander Petrunkevitch (*Amer. Jour. Science* 243 (June): 320-329, 1 pl., 8 figs. 1945) published the first records of arthropods in American calcite deposits, based on onyx marble from Bonner Quarry of the Southwest Onyx and Marble Company, located in a canyon the north side of Black Mesa about ten miles southwest of Ashfork, Arizona. He included a description of the geologic formation by Prof. Edwin D. McKee, Assistant Director of the Museum of Northern Arizona, at Flagstaff, Ariz.

According to Prof. McKee the onyx is "post faulting," or was formed since the middle of Cenozoic time, that is Upper Miocene

or Pliocene, but is deposited in cracks and faults in Permian Supai formation.

Evidently the Arthropods were washed into or drowned in calcite saturated waters and thus preserved.

Dr. Petrunkevitch erected a family Calcitronidae in the Order Schizomida, which was formerly known as the family Schizonotidae in the Suborder Uropygi of Order Pedipalpi. The type genus of the order is *Schizomus* Cook 1899 (*Schizonotus* Thorell 1888 preoccupied).

The first fossil species in this new order he described as *Calcitro fisheri*. Two specimens were seen and described with drawings and photographs.

Recently Mr. Fritz W. Schmidt of Long Beach handed the writer a third onyx pen base in which were visible at different levels six specimens, five of them belonging in the pedipalpid arachnids, and one a primitive japygid. This last is the first record of a fossil japygid, and the first record of any insect fossil in onyx.

2. NEW PEDIPALPIDS FROM ONYX MARBLE.

The onyx pen base now at hand has at the surface a very distinct pedipalpid, and deeper in the onyx are four smaller specimens probably younger forms, though possibly an entirely different species.

Petrunkevitch separated his *Calcitro* from Schizomidae on the number of tarsal joints, the Schizomid genera *Schizomus*, *Trithyreus*, and *Stenochrus* having three tarsal joints on each of the second, third and fourth pairs of legs; while *Calcitro* has five tarsal joints on the second pair, and four each on the third and fourth pairs. The present specimen has, as nearly as I can make out, but two tarsal joints and metatarsus on the second, third, and fourth pairs. On many other characters it differs generically from *Calcitro*.

Since the dorsal plate is not discernible it is impossible to determine whether this has the character of Thelyphonidae or Scizomidae, but it seems better to temporarily align it with the Thelyphonidae.

Genus ONYCHOTHELYPHONUS, new genus.

Type *O. bonneri* new species.

A thelyphonid having two last abdominal segments cylindrical, and the preceding segment much smaller and narrower than the other segments; caudal appendage with seven segments. All legs long and slender in the order 4, 1, 3, 2. Tarsal joints three in

first pair, and two each on the other pairs. Coxae contiguous on median line in second and third pairs, but separated by abdominal process in fourth pair.

ONYCHOTHELYPHONUS BONNERI, new species (Figure 1 of Plate 34.)

Type in Los Angeles County Museum Fossil Insect Collection, No. BQ1.

The specimen is on its back, just below the surface of the plaque, and is complete except for the hand of the left pedipalp, the entire right pedipalp, and the chelicera. The last three joints of the second right leg are broken off, but lie just beyond.

This thelyphonid differs from *Calcitro fisheri* in having stout, short jointed pedipalpi, with a short inner apical tooth on tibia; very small pedipalpal sternal plates; a longitudinally divided sternum between front legs; absence of anterior apical tooth on second coxae; first legs with three long tarsal joints; other legs with two long tarsal joints; ninth abdominal short, much narrower than eighth, but wider than the cylindrical tenth and eleventh segments; tail seven jointed.

Its measurements are: total length from anterior end of pedipalpal coxae to tip of tail 3.64 mm.; length of tail 0.44 mm.; base of abdomen to base of tail 2.12 mm.; greatest width of abdomen 0.84.; width of last two segments 0.32 and 0.28 mm. The order

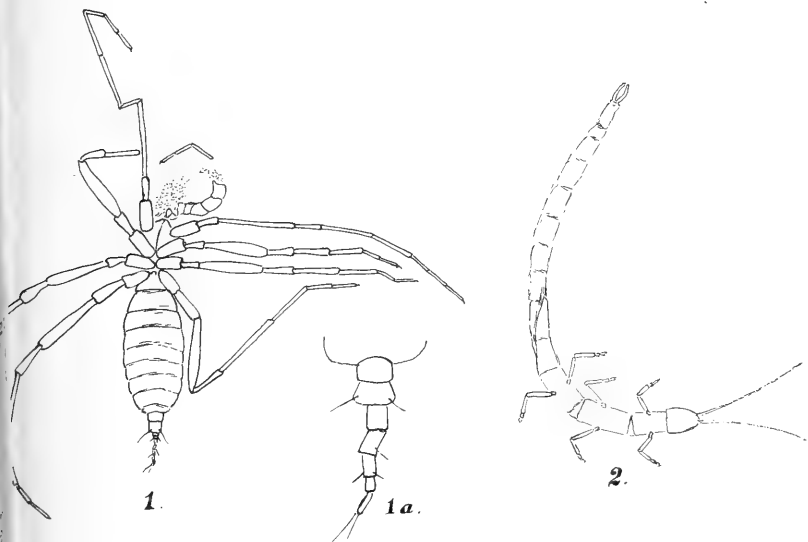


PLATE 34

of the legs is 4, 1, 3, 2. The surface of the ventral segments and femora is closely deeply transversely pitted.

LEG MEASUREMENTS IN MM.

Appendage	Coxa	Trochanter	Femur	Patella	Tibia	Metatarsus	Tarsus	Total
Pedipalpi	0.08	0.04	0.20	0.24	0.20	missing	missing	
Leg I	0.40	0.28	1.04	0.38	0.74	0.60	0.92	4.36
Leg II	0.44	0.28	0.88	0.36	0.48	0.44	0.52	3.40
Leg III	0.36	0.24	0.88	0.40	0.64	0.52	0.56	3.60
Leg IV	0.36	0.44	1.00	0.48	0.96	0.64	0.68	4.56

The other four specimens are deeper in the onyx and more decomposed, as well as much smaller. Whether they are younger specimens of the same creature or another species has not yet been determined.

3. A PRIMITIVE THYSANURAN FROM ONYX MARBLE.

Just 65 mm. from the *Onychothelyphonus* there is an insect specimen belonging to the Order Dicellura, Family Japygidae; probably the oldest fossil yet found in this order. The body is greatly distended and largely reduced to a skin.

Genus ONYCHOJAPYX, new genus.

A japygid with simple unjointed, untoother caudal cerci, two jointed tarsi.

ONYCHOJAPYX SCHMIDTI, new species (Figure 2 of Plate 34).

Named in honor of Fritz W. Schmidt, through whose kindness the material came to hand.

Type in Los Angeles County Museum Fossil Insect Collection, No. BQ 2.

The abdomen is twisted over, but the anterior portion is the ventral aspect.

Length of specimen as curved 4.80 mm., straightened 6.32 mm. Length of head 0.40 mm.; antennae 1.60 mm.; prothorax 0.48 mm.; mesothorax 0.72 mm.; metathorax 0.64 mm.; abdomen including cerci 4.08 mm.; cerci 0.32 mm.

The legs are simple and of the following pattern:

Coxa	I. 0.08mm.	II. 0.08mm.	III. 0.08mm.
Femur	0.24	0.32	0.32
Tibia	0.16	0.24	0.24
Tarsus	0.16	0.16	0.16

The slender antennae are many jointed.

This insect is especially interesting because so few thysanuran insects have ever been found fossil, and because of their fragile nature are hardly to be expected.

WHEN DOES A THING BECOME A FOSSIL?

By W. DWIGHT PIERCE

The writer has arrived at the threshold of paleontology by the back door, having been originally asked to determine the fragments of beetles found in the La Brea asphalt at Los Angeles. This study has led on and on into other fields of fossil insects, but still there hangs overhead the question—When does a thing become a fossil? No one can give an adequate answer.

It is not a question of mineralization or petrification, for many specimens are found that are unquestionably classed as fossils and yet have not been altered in their nature. On the other hand, by certain chemical processes we can mineralize a specimen completely and permanently in the laboratory.

It is not a question of extinction, for many specimens associated with validly designated fossils are still extant. And on the other hand some animals and insects have become extinct in the last century. Some insect genera extend back to the Eocene times, with little change.

It is not a question of decomposition because the Mastodons frozen in the Arctic ice are still in perfect flesh. Decomposition starts within a day or two after death, except when the animal is preserved by chemical or by ice.

When a wasp stings a spider it puts it into a perfect state of preservation which lasts for months; how long, has not been tested.

There is apparently some delicate little element of time involved. If it is 5,000 years old it is not a fossil in the eyes of some paleontologists, but if it is 10,000 years it may be. If it is 100,000 years old there is no question about its being a fossil; and yet it may look and be exactly like it was shortly after the creature died. But should antiquity alone be a criterion for the beginning of a science?

What is the exact minute, day, year, decade, century, or millennium at which our paleontologists will accept a specimen as in the realm of paleontology?

If a part of an animal or plant becomes surrounded by materials which will henceforth preserve it in the same condition for millennia of time, with pressure the only condition changing, why is it not a fossil from the minute of such embedment? As time rolls on, the superincumbent layers of materials will press

and condense the materials below, and perhaps the specimen will gradually be pressed out of its original shape until it lies in one plane. But it was a fossil long before that, even in the eyes of the most strict paleontologist.

The writer has had occasion to study several types of fossil formation and is naturally in a quandary as to what that mysterious hour is that takes a thing out of the realm of ordinary biology into the realm of paleontology.

The most beautiful insect fossils known to us are those found in Baltic amber, which was formed from the exudates of ancient conifers and entrapped insects while it was in its sticky state. But many trees today exude gums (balsam, resin, copal, damar), that entrap ants and other insects, and when these pieces of gum fall to the ground they become a part of the forest carpet. As time goes on the gum hardens and very little change will take place between the first month of hardening and centuries later. When does gum embedment become a fossil?

Along volcanic faults hot springs often bring up water heavily impregnated with calcite and other salts, and sometimes these salts crystallize very quickly, especially upon insects, sticks and other objects in the water. The specimens become saturated with the salts, and are a part of the deposit. In time this deposit becomes onyx or marble. Onyx-marble has been continuously forming in some areas of Arizona, California, and Baja California since Miocene times and perhaps long before that. The preservation of insects in this onyx-marble is almost as perfect as that in amber. Is there a time before which the specimens in onyx are fossil, and after which they are not?

Peat is an accumulation of leaves, stems, and other plant materials in a boggy place. Insect remains are often included in the mass. As time goes on, this material becomes packed in tightly compacted layers. When the peat comes under additional pressure such as that of a glacier or the result of a land slide, it is even more tightly pressed to form lignite, and the same insects are present, perhaps more crushed.

When in this gradually developing compression does peat or lignite come into the realm of paleontology? If either is interglacial it is Pleistocene, and accepted. But is it not the same and in the same condition even if formed much later than during Pleistocene?

Asphalt embedment has been going on since middle Pleistocene, and continues today. The insect caught in the bitumen is often immediately submerged, although at other places may not become completely surrounded by the material for months. After

final complete embedding, it becomes a part of the continual deposition of such material until there may be thousands of layers above it. The condition of the insect fragments after the disintegration of the soft tissues, remains constant throughout the centuries. Do not the materials of paleontology, as concerns bituminous embedment, start with the present day catches and extend back in unbroken series to the earliest evidences of petroleum seepage?

In these four fields the paleontologist can study the changes in insects from today back to the inter-glacial periods. In what actual time do his studies enter the field of paleontology? Does not the actual field of paleontology begin with the complete encasement of an object?

On November 25, 1940, Mr. G. P. Kanakoff collected a piece of soft, clayey soil on San Nicolas Island, which had the trails of fox, bird, tenebrionid beetles and other creatures at the margin of a sandy beach. By 1946 this specimen was hard rock. If this portion of beach had suddenly been covered by a different kind of dust or soil, those trails would have been preserved. The hardening process might have taken longer at this site, but the record was imprisoned. How many years must elapse before such a record of present day life comes into the realm of the paleontologist? Does it become a fossil series of prints as soon as the record is made permanent by imprisonment or sealing?

The introduction of ecological thinking into paleontology will necessitate our recognition of such materials as incipient fossils.

At any rate, in the studies we are making of recent Pleistocene life, we have continuous series of materials for all periods of time, and our studies must take into account the transitions in structure, the interventions of climatic change, and the changes of supporting life.

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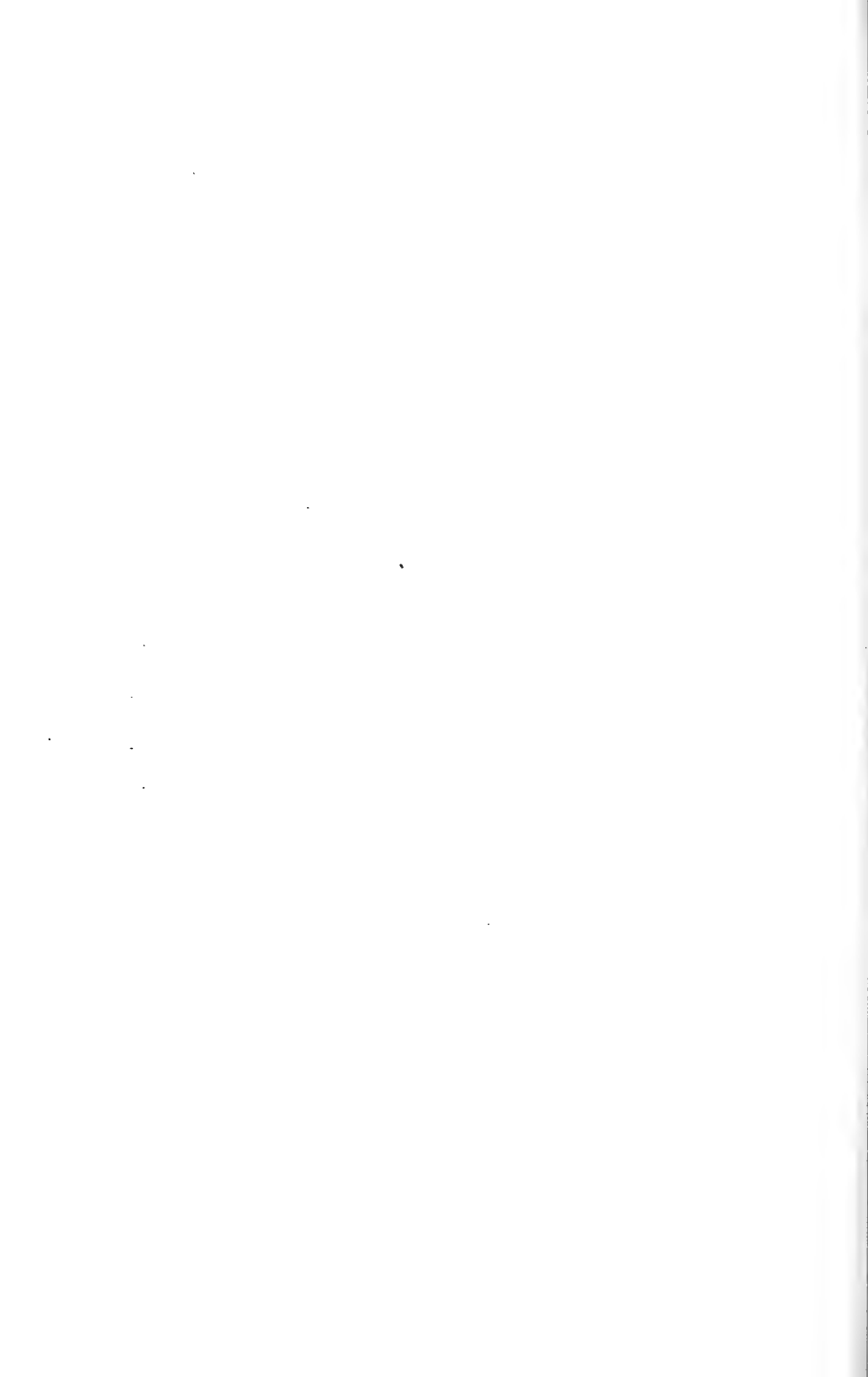
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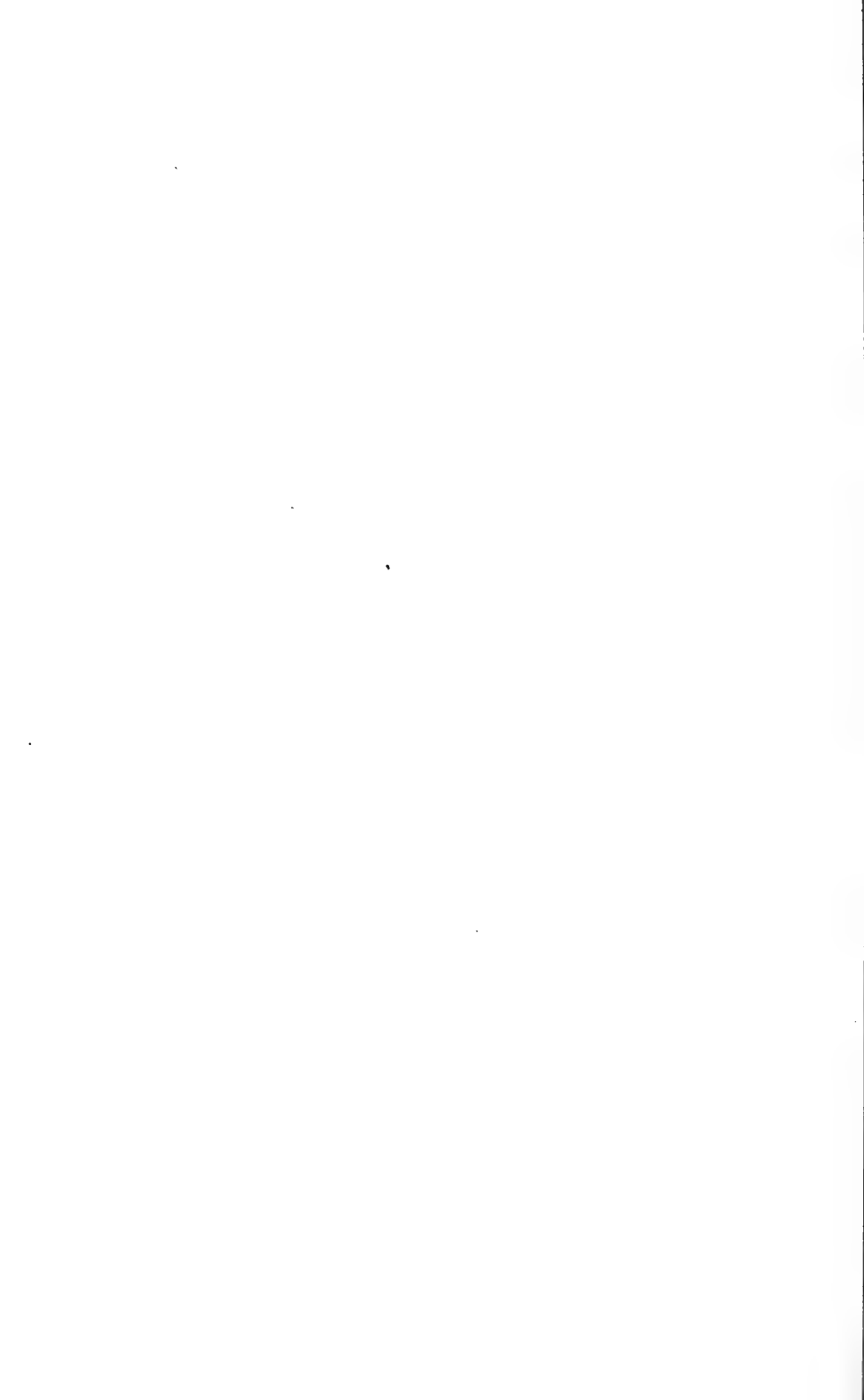


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MITCHELL'S CAVERNS, CALIFORNIA

By K. O. EMERY and W. H. EASTON
University of Southern California

INTRODUCTION

Occasional geological field trips are made to the Mojave Desert of California to offer students at the University of Southern California training in field investigations. During several of the trips visits were made to Mitchell's Caverns, which proved to be so unusual that it was thought advisable to publish an account of the caves and of their origin. In short, an explanation is needed to account for the present position of the caves above the water-table, whereas the evidence indicates that the caves developed below the water-table.

Mitchell's Caverns (Fig. 4 of Plate 4) are located in the Providence Mountains of San Bernardino County, California. They lie at an elevation of about 4400 feet on the east slope of the central portion of the mountains (Fig. 7). West of the caves the mountains rise to an elevation of 6970 feet at Fountain Peak, whereas the slope to the east descends to an elevation of only 1700 feet on the floor of the adjoining basin (which is sometimes called Clipper Valley). A graded road across the valley connects the caves with the nearest settlement, Essex, 22 miles distant and on U. S. Highway 66 about 114 miles east of Barstow.

The Providence Mountains lie more or less in the central part of the Mojave Desert. Rainfall is scant, and although official figures are not available, the average annual precipitation in basins of the region is about three inches. The exceedingly sparse vegetation includes creosote bush, yucca, barrel cactus, mormon tea, and associated desert species. On the other hand, evergreens on the high part of the mountains bear witness to a greater supply of water at high elevations.

This region has been inhabited intermittently during at least the past 500 years by a band of desert Shoshonean Indians generally called the Chemeheuvi ("fish-eaters"). One of their burials has been found in the south cave; their torches, baskets, and mats have been noted in both caves; and a drawing is visible on the wall of the north cave. The south cave, Tecopa, is named after the last Shoshonean chief. The north one, El Pakiva, means "Devil's House" (Plate 1).

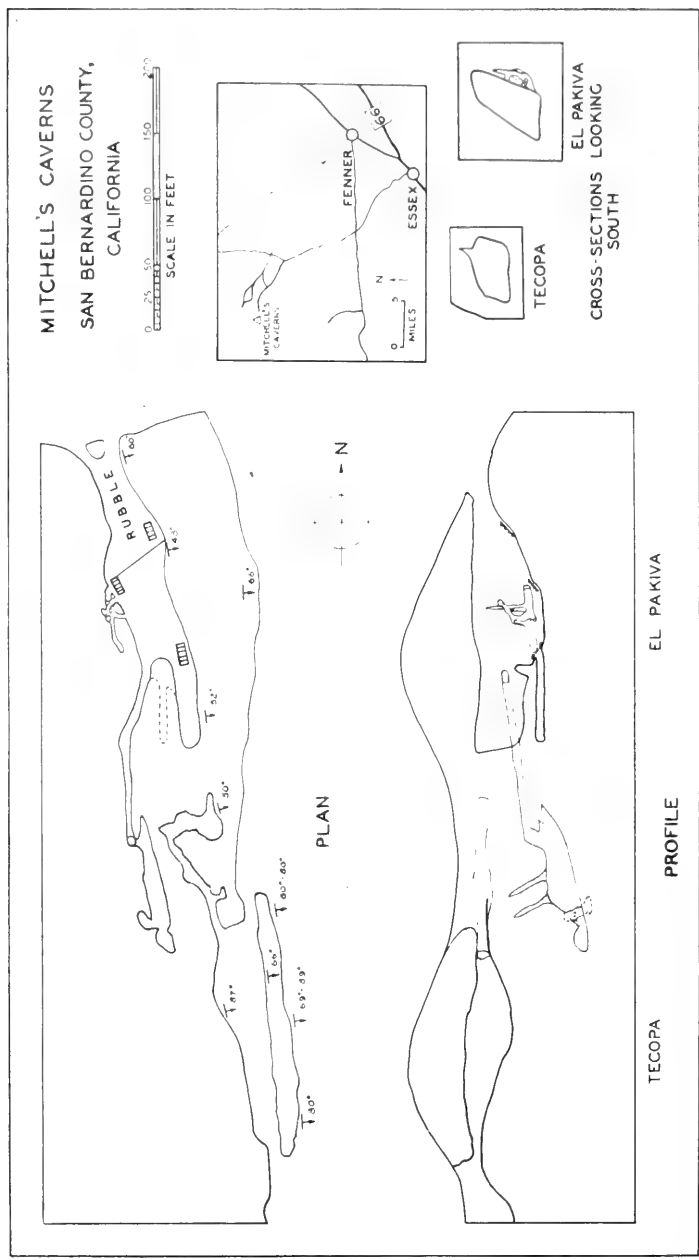


PLATE 1
Plan, side, and end views of Mitchell's Caverns.

ACKNOWLEDGMENTS

The writers are pleased to acknowledge the assistance of numerous students at the University of Southern California during the mapping of the caves and in investigations pertinent to the report. Chief among these students are Messrs. R. J. Burnside, R. F. Dill, W. R. Heiner, W. T. Lee, W. J. Lewis, H. J. Reade, and J. F. Riccio. Dr. John C. Hazzard obligingly furnished some material from an unpublished paper of his on the Providence Mountains. Miss Martha Berry and Mr. Gordon Hughes have kindly provided us with some geographical and historical material. All persons interested in the conduct of the field work are grateful to Mr. and Mrs. J. E. Mitchell, owners and managers of Mitchell's Caverns, for their courtesy, cooperation, and hospitality during visits to the caves.

STRATIGRAPHY

The oldest rock in the Providence Mountains is probably the green granite which crops out east of the caves. Elsewhere in the mountains 7000 feet of strata representing Cambrian, Devonian, and Mississippian time are known. (Hazzard, 1938). Overlying them are 3000 feet of Pennsylvanian (?) and Permian rocks which comprise the oldest strata actually cropping out in the immediate vicinity of the caves. The locally missing portions of the column have been cut out by a fault which brings the green granite into contact with the cavernous limestone section. Triassic sediments were deposited on the Permian strata but now they are exposed only northwest of Fountain Peak. (Hazzard, 1937). They are overlain and intruded by Tertiary volcanic rocks which form the peak proper above the caves.

Mitchell's Caverns are developed in the lower portion of a thick sequence of marine limestones that crop out prominently on the mountain side for several miles north and south of the caves.

Lithologic control required by classical theory of development of limestone caves by solution is shown in the stratigraphic section (Plate 2). The three limestones in which the caves have formed are grey, massive, dense, fine-grained, and contain only small percentages of chert and dolomite. Exposed strata adjacent to the cave-forming limestones are impure (sandy or shaly) thin-bedded limestones. In each instance these are less soluble, but, owing to their thin bedding, they weather more rapidly at the surface under desert conditions than do the cave-formers. Thus, the greater solubility of the massive strata has led to restriction of caves to them, whereas their greater resistance to mechanical weathering has left them more prominent in outcrops.

Paleontologic evidence of the age of the cavernous limestones was obtained by study of collections of fossils noted by crosses on Plate 2. The fauna includes the particularly significant fusulines *Triticites californicus*, *Schwagerina aculeata*, *S. providens*,

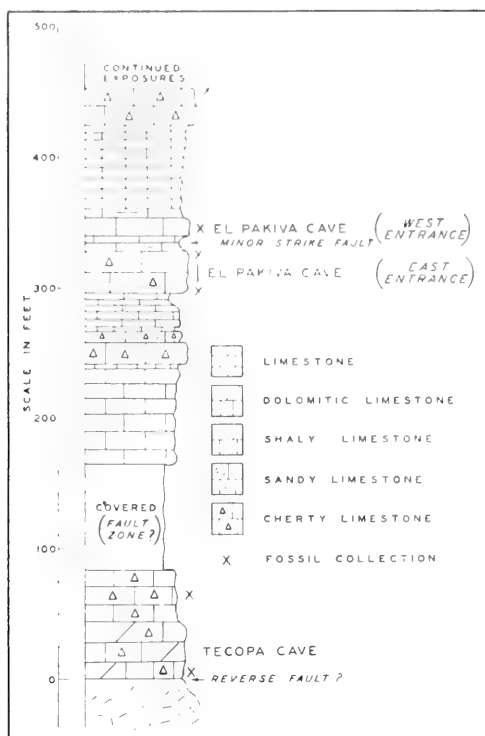


PLATE 2

Partial columnar section of the limestone strata exposed at and near Mitchell's Caverns. Relative resistance to weathering is indicated by the irregularity of the right-hand side of the column. Thicknesses may be somewhat in error due to strike-faulting.

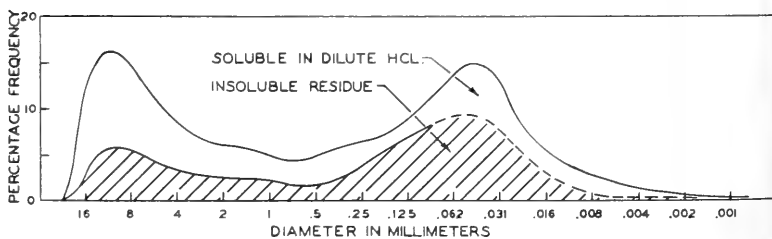


PLATE 3

Grain-size distribution of cave dust and percentage of insoluble residue in each grade-size.

S. ? multispira, *Schwagerina?* sp., and *Pseudoschwagerina roose-leri*; the brachiopod *Neospirifer condor*; the large gastropod *Omphalotrochus* sp. and various corals upon which later publication is intended. All species identified above are restricted to the Permian System and therefore the limestones are somewhat in excess of 200,000,000 years old. The section at Mitchell's Caverns is of the same general age as are the Permian strata studied by Thompson and Hazzard (1946, pp. 37-40) 1½ miles to the north of the caves. It is therefore assigned to the local Bird Spring formation, which in turn, is referable to the Wolfcamp Group of the classic Permian of Texas.

The youngest strata in the region crop out in the escarpment of wild Horse Mesa in the northern portion of Clipper Valley east of the mountains (Fig. 6 of Plate 4). Dr. John C. Hazzard informs us that the sedimentary and volcanic rocks there can be dated as Tertiary (Miocene) by the fossil flora. He also has demonstrated the presence of rubble of the lithologic types present in the Providence Mountains interbedded with the volcanic rocks of Wild Horse Mesa.

STRUCTURE

The structural block which forms the Providence Mountains trends north-south. This mountain is topographically similar to scores of others which, with the intervening and surrounding alluvium-filled basins, constitute the Basin and Range Physiographic Providence. Current geological opinion leans toward assigning most of the ranges to normal faulting, whereby the basins have dropped along a fault line at the juncture of each basin and adjacent range. The floors of the basins are mantled with alluvium which usually prevents study of the underlying bedrock and of the faults.

The Permian limestone of Mitchell's Caverns is in fault contact with granite several hundred feet down the slope eastward from the caves. We recognize that the demonstration of the structural relationship of the Providence Mountains to Clipper Valley constitutes a sizable problem in structural geology in itself (Baker, 1913). The problem is not discussed in detail in this paper because we are convinced that the caves developed after the faulting and folding of the strata.

It must be mentioned, however, that three systems of faults exist. The first and commonest are parallel to the bedding planes. Several of these faults were observed in the region; one of them is in the impure thin-bedded limestones separating the east and west entrances of El Pakiva Cave. The second type of fault is vertical and cuts east-west across the beds. The most pertinent one passes between Tecopa and El Pakiva caves, coinciding with a broad reëntrant on the flank of the mountainside. About 300 feet of lateral movement has brought the massive limestones of

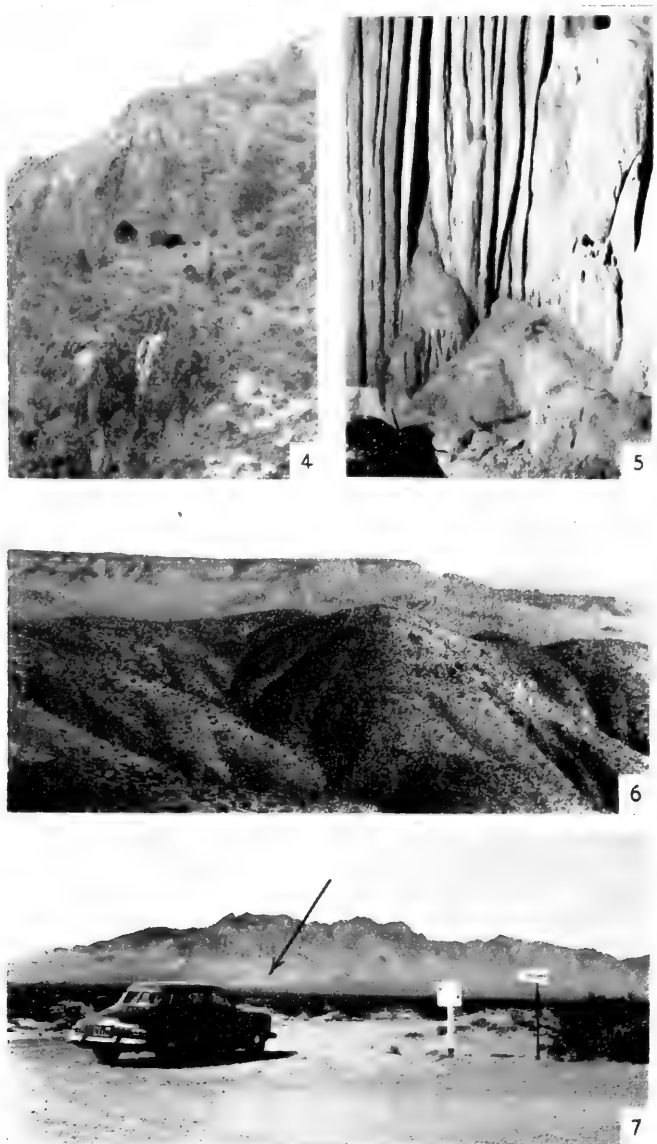


PLATE 4

FIGURES 4-7. Fig. 4, North entrances of El Pakiva Cave. 5, Fractured and recemented drip curtain in Tecopa Cave (upper center); horizontal ridges and shelves (lower half.) 6, Wild Horse Mesa east of Clipper Valley; lower granitic slopes of Providence Mountains in foreground. 7, Providence Mountains viewed westward across Clipper Valley: arrow indicates Mitchell's Caverns.

the two main caves into alignment. Faults of the third system are horizontal. One is exposed in the bank of the ravine below the entrances of El Pakiva Cave, where the upper strata have been thrust about 300 feet eastward over the lower strata.

Various local systems of fractures and joints were observed at the caves. Most are oblique to the fault planes.

It is difficult to determine exactly the date of the mountain-building. The youngest sedimentary rocks certainly involved in the uplift of the mountain are of Triassic age. These are succeeded by Tertiary (?) rhyolite which makes up the dissected volcanic plug, Fountain Peak. The age of this extinct volcano could not be determined other than as post-Triassic. It may have been active during the mountain-building. The next younger datable strata above the Triassic are of Miocene age. These, of which Wild Horse Mesa is formed, extend to within a few hundred yards of the north end of the Providence Mountains, but their structural relationship to the mountain is obscured by an intervening valley.

In summary, the Providence Mountains were faulted and folded most severely after Triassic and before Miocene times. Minor faulting and slight warping took place after the Miocene.

CAVES

SHAPE

Only two caves are easily accessible, but they are the largest ones in the immediate area (Plate 1). These two main caves are on about the same level, but a secondary chamber that is entered through a small well and passage at the south end of El Pakiva Cave is about 50 feet lower. El Pakiva Cave has two entrances (Fig. 4 of Plate 4) in different strata separated by a pillar-like mass consisting of 12 feet of impure limestone containing a minor bedding-plane fault. The main chambers of both caves are elongate and parallel with the strike of the limestone, and the sloping sides of each cave reflect the dip of the rocks. The roof of each, though irregular, is fairly horizontal, in contrast to the concave floor. One or more series of small anastomosing passages in each cave are more or less circular in cross-section with sinuous traces in both horizontal and vertical aspects. Most outstanding of these is one (Fig. 11 of Plate 5) within the west wall of El Pakiva Cave, which spirals and divides in a manner suggestive of the canals of the human ear.

Several other caves are located within a half-mile, both north and south of the main cave. These are smaller, either originally or because of natural filling. All are within the same general stratigraphic horizon and are at the same general elevation above sea level; therefore, they originally may have been interconnected.



PLATE 5

FIGURES 8-11. 8, Undercut stalagmite in south end of El Pakiva Cave. 9, Stalactites along fractures in roof of El Pakiva Cave. 10, Rubble near mouth of El Pakiva Cave. 11, Phreatic tube (diameter 2 feet) in west wall of El Pakiva Cave.

FILL

After the period of active cave formation, filling commenced. This took three forms: collapse breccia, dripstone, and cave dust—listed in order of probable decreasing volume. Blocks whose longest dimensions exceed 10 feet lie scattered about the floor, especially near the entrances of the caves (Fig. 10 of Plate 5). In fact, the sloping ends of the concave floors may well be the result of the accumulation of collapse breccia from rock falls mixed with material washed into the caves from the hillsides.

The second component of cave filling is dripstone, which occurs as stalactites, stalagmites, columns, drip curtains, rimmed brackets, and veneer. Dripstone is most abundant by far at the south end of El Pakiva Cave (Fig. 9) and at the north end of Tecopa Cave. This localization of dripstone coincides with the small transverse (east-west) fault zone, where a higher permeability to ground water is to be expected. Both the long narrow passage and the chamber at the north end of Tecopa Cave are almost completely lined by dripstone. In fact, that chamber was reached by Mr. Mitchell only after blasting through several feet of dripstone. A smaller chamber can be seen through a hole in the drip curtain high on the back wall of El Pakiva Cave. It seems probable, therefore, that Tecopa and El Pakiva Caves were once continuous but that the accumulation of dripstone along the transverse fault zone has separated them. A thin veneer of dripstone covers most of the sloping west walls of the caves, and small stalagmites have grown up from that surface. Some of the fallen blocks are partly covered by dripstone, whereas others are barren, indicating that some blocks fell before or during, and some fell after the time of active formation of dripstone (Fig. 10). Only two stalactites were observed to have any film or drip of water, so it seems likely that negligible growth occurs now. Virtually all of the dripstone is vertical; thus, structural tilt has not occurred after deposition of the dripstone. Some of the dripstone has been broken, however (Fig. 5 of Plate 4), during the late history of the caves, especially at the north end of Tecopa Cave, where a large compound stalactite was broken off and re-cemented by dripstone. Selective stains applied in the laboratory showed that the dripstone consists of calcite with no aragonite or dolomite.

A thin layer of cave dust covered the walls of the large caves when they were opened, and a similar layer is still present in the lower secondary chamber. Cave dust also forms the flat central part of the floor of both Tecopa and El Pakiva Caves (Figs. 8, 10 of Plate 5). An excavation in the middle of Tecopa Cave passed through more than 30 feet of cave dust, according to Mr. Mitchell. Samples of cave dust collected from the floor consist of buff-colored debris of pebble, sand, silt, and clay size, together

with a generally small amount of organic material consisting of seeds, nuts, stems, leaves, and rat excrement. A grain-size analysis of a composite sample collected from four localities, two in each of the main caves, is presented in Plate 3. The percentage of material in each size grade that was insoluble in dilute hydrochloric acid is also given. It is evident from the graph that the finer components contain somewhat higher percentages of insoluble material, leading to the conclusion that they are natural insoluble residue left by the acid reaction of percolating ground water. The larger fragments consist of insoluble siliceous remains of fossils and of small bits of limestone which have fallen or have been washed from the roof and walls.

Overall analysis of the cave dust showed that insoluble residue averages 57 per cent by weight. Similar analyses showed that the limestone averages 11 per cent insoluble residue, whereas the dripstone averages only 0.8 per cent. Concentric zonation of the dripstone evidently owes its origin to variations in amount of insoluble dust trapped by the accumulating layers of calcium carbonate. Probably most of this dust is deposited during relatively dry periods when all of the water evaporates on the dripstone, leaving its entire load of calcium carbonate and dust. During wet periods the flow is probably sufficient to flush most of the dust past the dripstone to the cave floor. The water which reaches the floor can percolate through the cave dust after depositing its load of dust at the top surface, but it should be able to carry away most of its load of dissolved material. This process accounts for the higher percentage of insoluble residue in the cave dust as compared with that in the dripstone and limestone. If one accepts the foregoing analyses, namely that the average insoluble residue in the limestone is 11 per cent and that in the cave dust, 57 per cent, one finds that the weathering of one foot of limestone would produce 0.2 foot of cave dust. If the cave dust came only from the open space from which limestone has been dissolved, and if this space averages 30 feet in height plus the thickness of cave dust, then the average thickness of cave dust produced would be 7.2 feet. However, at present, the flat floor of cave dust comprises only about one-fourth of the area of the cave, the rest being collapse breccia and dripstone. If all cave dust be assumed to be concentrated in that area alone, the total thickness would be more than 30 feet, a conclusion which is not incompatible with the results of the excavation in Tecopa Cave. In reality, some debris must have been washed into the caves, while much material was probably carried out by escaping water, both during cave formation and at present. In fact, the flat base of a large mass of stalagmitic dripstone attached to the wall in the back of El Pakiva Cave is two feet above the floor of cave dust, proving that some cave dust has been removed after the deposition of dripstone (Fig. 8 of Plate 5).

ORIGIN

DATA FROM CAVES

The characteristics of the caves and of their environment permit reasonably accurate reconstruction of their history of development. The alignment of these caves and of others in the vicinity in the same general beds and at the same general level suggests that all are remnants of an early single long cave formed in the thickest and most soluble limestone beds. Small passages with circular cross-sections, branching pattern, and local steep axes indicate a phreatic origin (Bretz, 1942)—that is, that solution occurred below the water table (Fig. 11 of Plate 5). Extensive rock falls and partial masking by dripstone and cave dust in the larger chambers of each cave have generally removed or obscured critical features there. After the period of cave development, enlargement stopped abruptly as indicated by the absence of caves at much lower levels on the mountain slope, and by the presence of only minor evidence of vadose (that is, above-water-table) erosion of these caves (Fig. 5 of Plate 4). The evidence of vadose action consists of slight notching of flumes, local flattening of passage roofs, and the development of a few small horizontal shelves in the walls of passages. All these features are poorly developed.

Filling of the caves may have begun concurrently with their excavation because the cave dust consists mostly of insoluble material originally in the limestone. When released by solution, this material could have been deposited on the floor of the cave and not have been eroded by the sluggish phreatic currents. Its deposition continued after the phreatic regimen and even today cave dust is washed down the walls and the dripstone to the floor. During this later stage both dripstone and collapse breccia contributed to the cave filling. Included in the debris of two completely filled caves in the vicinity are pieces of rhyolite.

REGIONAL DATA

A striking paradox exists because the caves appear to have been formed below the water table and yet they are now perched high on the flanks of the mountain well above the water table (Fig. 7 of Plate 4). Any explanation of the origin of the caves must involve a method of having them once below the water table. Only two possibilities can be entertained.

1. The caves developed before the mountain came into existence.

2. The caves developed after the mountain came into existence.

Two difficulties confront the first case. The caves lie in a

region of minor strike faulting and are quite close to a major fault. It seems very unlikely that they could have survived the application of forces necessary to deform the strata during mountain building. The mechanics of the deformation require a rotational motion of the block, yet there is no evidence that the caves have been tilted, and certainly not tilted subsequent to the formation of dripstone.

We are left with the second case to consider. If the mountain existed before the caves were formed, then some material must have been heaped up against the side of the mountain to a level at least as high as the upper reaches of the caves in order to provide a medium in which the water table could rise high enough to encompass the strata in which the caves were developed. The only traces of basin fill higher than the present floor of Clipper Valley are a few low mounds several miles east of the caves. These erosional outliers of Wild Horse Mesa indicate that the mesa was formerly much more extensive than it is now. Its former surface altitude east of and near the mountain can be approximated in two ways. If one extrapolates the surface level of the present flat-lying southern margin of the mesa, it will be found to lie a few hundred feet above the cave mouths. One can sight along a level from the caves to the mesa and establish this relationship. Secondly, the slope of the mountain just above the caves is interrupted by a wide, much-eroded bench which forms an irregular shoulder extending sporadically along the eastern front of the mountain. This is believed to mark the former baselevel of erosion of the mountain at the level of the mesa. Erosion then and subsequently has reduced the thickness of the east wall of Tecopa Cave to only five feet. That of El Pakiva Cave is fifteen to thirty feet thick. The outside of both walls constitutes a steep, barren, rocky, dip slope.

SEQUENCE OF EVENTS

During the Permian (late Paleozoic Era) the ocean invaded the region and a thick deposit of limestones was formed. After various other advances and retreats of the seas, the region was subjected to a period of mountain-making sometime in the late Mesozoic Era or possibly in the early Cenozoic Era. At this time large-scale faulting and folding took place. Movement along one of these faults (or zone of faults) either caused at least some of the deeply buried (Pre-Paleozoic) granite to ride upward into contact with the later Paleozoic limestone, or the main mass of the Providence Mountains was thrust over the granite.

After the uplift of the mountains began, Tertiary terrestrial sediments, including material eroded from the mountains, began to accumulate in the basin, ending with a series of volcanic rocks. It is supposed that the basin fill extended several hundred feet

above the level of the present caves. Ground water saturated the rocks of this ancestral Wild Horse Mesa and also the neighboring Permian rocks to a level at least as far up as the caves. Solution of the limestone then began, with the development of sinuous passages and other features characteristic of phreatic caves. During the early wide extent of the mesa the upper portion of the east flank of the mountain was eroded westward, whereas the buried portion was not eroded, being shielded by the strata of the mesa.

In time, erosion of the formerly extensive mesa progressed to such an extent that the drainage system had cut back into the mesa and allowed the ground water level to fall. With the fall of the water table minor evidence of vadose circulation was developed in the caves.

The second cycle of cave history then began, in which dripstone and other filling accumulated. While this was going on, the ravines or gullies which started earlier to develop their channels high on the mountain above the caves, coursed over the exhumed lower flanks of the mountain and cut deep V-shaped gorges which now end rather abruptly at the margin of the basin. These gorges have been cut across the earlier extensive cave, separating it into discontinuous sections. Completely filled sections of the ancient cave are visible on the north side of the gully across from the mouth of El Pakiva Cave, where they occupy the same strata as do Mitchell's Caverns. Elsewhere along the front, fragments or blocks of dripstone lie in the rubble of various dry water courses, testifying to the presence of other sections of the cave along the mountain front. Since the partial removal of the mesa, the superficial rocks have been eroded from the mountain flank, leaving the caves very near the surface of the ground. We observed no indication that the caves are evolving now, probably because of the aridity of the country.

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CONTRIBUTIONS FROM LOS ANGELES COUNTY MUSEUM—CHANNEL ISLANDS BIOLOGICAL SURVEY

No. 35. OCCURRENCE OF THE FALSE KILLER WHALE *PSEUDORCA*, ON THE CALIFORNIA COAST

By KENNETH E. STAGER and WILLIAM G. REEDER
Los Angeles County Museum, Los Angeles, California

Although the false killer whale, *Pseudorca crassidens* (Owen) has at times come ashore in rather large numbers at scattered localities throughout the world, records of its occurrence along the west coast of North and South America are few. The most northerly record on this coast is a skull (Wash. State Mus. No. 12515), obtained from a fresh carcass in Puget Sound, Washington, on May 15, 1937 (Scheffer, 1948). The specimen previously establishing *Pseudorca* as a resident of west coast waters was a weathered skull and incomplete skeleton taken by the U. S. Fish Commission steamer *Albatross* at Pichilique Bay, near La Paz, Lower California, on April 29, 1888 (U.S.N.M. No. 23282).

Garrod (1924), records the number of specimens in museums as being under thirty. Therefore, in view of the rarity of its occurrence, it is with considerable interest that we are able to record a definite record of the species from the coast of southern California. On July 10, 1949, while the writers were engaged in field activities on San Nicolas Island, Mr. Stute, a sailor from the naval base, called our attention to a small cetacean skull he had discovered on the south side of the island while on a fishing excursion to that area. Seeing our interest in the specimen, Mr. Stute presented us with the skull, which, although evidencing considerable weathering, was in excellent shape except for the absence of the teeth and lower mandibles.

The skull was identified as that of *Pseudorca crassidens*. Subsequent search through some heretofore unworked material collected for the Los Angeles County Museum by Mr. Jack C. von Bloeker Jr., on San Nicolas Island during the winter of 1940, revealed two additional skulls belonging to this species. In an effort to turn up still further cetacean records for San Nicolas Island, Mr. Reeder returned to the island on July 23, 1949. A systematic search along the rugged beaches and rocky exposures of the south side of the island resulted in the collection of a fourth skull and a number of ribs and vertebrae.

In order to clarify the picture of the presence of this interesting cetacean on San Nicolas Island, a brief description of the topography of the island and the location of the collection sta-

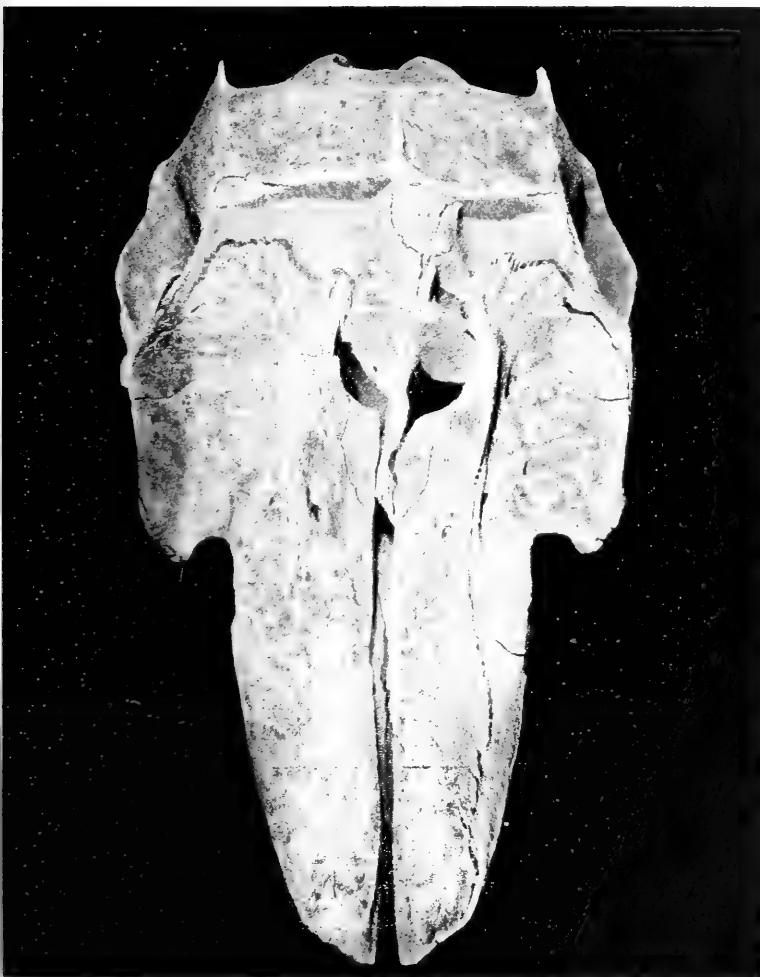


PLATE 6

Dorsal view of skull of *Pseudorca crassidens*, L.A.M. 8459.

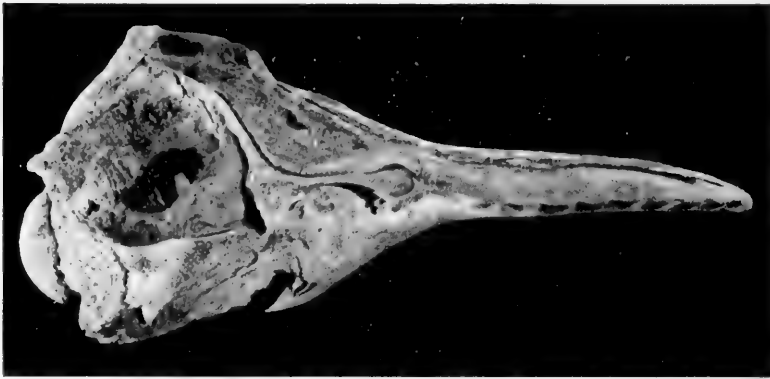


PLATE 7

Lateral view of skull of *Pseudorca crassidens*, L.A.M. 8459.

tions seems warranted. San Nicolas Island constitutes the outermost of the eight channel islands lying off the southern California coast, and is approximately 76 miles southwest of Los Angeles Harbor. Somewhat oval in shape, San Nicolas is $9\frac{1}{2}$ miles in length and $3\frac{1}{2}$ miles in width, with its long axis lying in an almost east-west direction. The eastern tip of the island is characterized by a long sand spit which extends seaward for a considerable distance. All stations of occurrence of the skeletal material of *Pseudorca* were along the south side of the island and involve a length of coastline approximately $3\frac{1}{2}$ miles long.

The south coast of the island consists of a rapidly ascending, highly dissected slope, which rises within a rather short distance



PLATE 8

Lateral view of skull and fused vertebræ of *Pseudorca crassidens*, L.A.M. 1860.



PLATE 9

Ventral view of fused group of first six cervical vertebræ
of *Pseudorca crassidens*, L.A.M. 8458.

to the main axial ridge and sloping mesa. Three of the skulls were found on this slope, from 75 to 300 yards from high tide line, and at an elevation of 10 to 30 feet above the normal high tide level. The fourth skull was found in the vicinity of an Indian shell mound located at an inlet known as "Dutch Harbor." The mound itself was but 100 feet from the normal high tide line. The skull and partial skeleton (L.A.M. 8458), collected 3 miles west of the sandspit, were found in close proximity to a partial skull and skeleton of the California gray whale, *Rhachianectes glaucus*. Whether the two species were beached at the same time is, of course, unknown. An unusually heavy storm could account for their deposition above the normal high tide mark.

A characteristic of the genus *Pseudorca* is the fusion of the first six or seven cervical vertebræ. An examination of the material at hand shows this condition to exist in the three specimens which include the cervical vertebræ. In two (L.A.M. 8458 and 8459), the first six cervical vertebræ are fused, while the seventh is unattached (Plate 9). The third specimen (L.A.M. 8460), shows anomalous development of these parts (Plates 8 and 10). In this specimen, the entire cervical series is joined; anteriorly, also, the atlas is ankylosed rigidly to the occipital condyles by a necrotic osteous growth, which has nearly obliterated the usual joint region. Both dorsally and ventrally, however, the line of fusion is evident as a more or less definite crack, which pene-

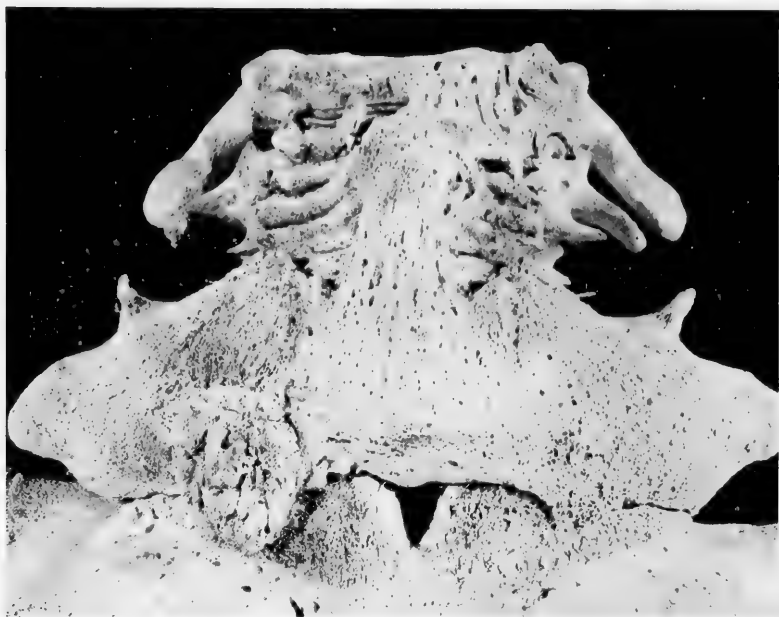


PLATE 10

Ventral view of occipital region of skull of *Pseudorca crassidens*,
L.A.M. 8460, with first eight vertebral elements fused thereto.

trates not over one-half inch into the normal joint area. Posteriorly, the seventh cervical vertebrae is fused on its ventral surface to the first thoracic vertebra by a continuation of the exostotic growth illustrated in Plate 10. An examination of the ventral surface of the fused vertebral elements shows the development of an extensive osteoma which has affected the greater part of this region, and resulting in an ankylosed condition in which the first eight vertebral elements are fused to, and form an extension of, the cranium. The osteoma is formed of an exceptionally porous type of bone tissue. The variance of the anomalous fused vertebral series from the normal may be seen by comparing Plates 9 and 10. The extent of necrotic growth is easily observed.

Undoubtedly, the movement of the animal, especially during rapid swimming, was hampered to a great extent by this pathologic condition. Also, and of probably greater importance, is the increased difficulty of feeding, as rapid movements of the head would have been impossible. The fact that the animal is

adult, however, shows that the handicap did not make existence impossible.

Reference to Table I indicates that the cranial measurements of the four specimens here reported are very similar to those given by Miller (1920). Two of our specimens (L.A.M. 8459 and 8460), are larger by small increments than any of the six skulls reported by Miller. However, the disparity is slight, and may be due, in part, to differences in technique of measurement.

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TABLE 1.—CRANIAL MEASUREMENTS OF *PSEUDORCA CRASSIDENS* (OWEN)

	8457	8458	8459	8460
Los Angeles County Museum Number.....	San Nicolas Island, Ventura County, California	San Nicolas Island, Ventura County, California	San Nicolas Island, Ventura County, California	San Nicolas Island, Ventura County, California
Locality.....	580 mm.	568 mm.	638 mm.	638 mm.
Maximum condylobasal length of skull.....	283	281	320	318 mm.
Maximum length of rostrum.....	193	181	202	204
Width of rostrum at base (antorbital notches).....	186	175	197	199
Width of rostrum 60 mm. anterior to antorbital notches.....	200	...	212	241
Breadth across preorbital angles of supraorbital processes.....	212	227	216	246
Breadth across postorbital angles of supraorbital processes.....	364	...	356	355
Zygomatic breadth.....	254	245	272	267
Width of braincase across parietals.....				
Maximum distance between outside margins of premaxillaries, just anterior to nasal openings.....	120	116	128	141

	R.	L.	R.	L.	R.	L.	R.	L.
Total number of teeth in upper tooth row.....	7	8	8	8	9	8	8	9
Length of upper tooth row.....	197	210	223	224	242	245	248	248
Posterior end of upper tooth row to end of premaxillary.....	...	225	240	239	261	259	...	...
Total number of teeth in lower tooth row.....	...	...	...	...	...	...	...	...
Length of lower tooth row.....	...	...	...	...	...	...	...	...
Posterior end of lower tooth row to end of mandible.....	...	...	...	...	...	...	...	...
Maximum length of mandible.....	...	...	...	...	...	...	...	...
Maximum height of mandible through coronoid.....
Length of symphysis.....

A NEW SPECIMEN OF *ACANTHODES MARSHI*

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A collection of fossils from the Coal Measures of Mazon Creek, Illinois, recently acquired by the Los Angeles County Museum, includes a nodule containing the scales of an acanthodian fish or "spiny shark," *Acanthodes marshi* Eastman. This species has previously been known only from the type specimen and a few fragments. The specimen in the Los Angeles County Museum (No. 1353) agrees with the type in the large size of the strongly convex, rhomboidal scales. A patch of scales about 6 by 10 cm. is preserved. Associated with these is a fin spine 47 mm. long and a portion of another elongate, flat bone, 63 mm. long, possibly a larger spine.

Eastman (1902, pp. 93-94) described two species of acanthodians from Mazon Creek. *A. marshi* is based upon scales of a large individual (Yale Peabody Museum No. 2803); several fin spines 7 to 9 cm. in length and one smaller specimen (Y. P. M. No. 2805) which shows the impression of the fin membrane behind a spine $2\frac{1}{2}$ cm. long were referred to the species. *A. beecheri* was founded on impressions of two small fishes, of which the larger (Y. P. M. No. 630) may be designated lectotype; these are about 5 cm. long, scaleless except along the lateral lines, and characterized by long pelvic and short pectoral fin spines. Watson (1937, pp. 111-112) has shown that during the growth of acanthodians ossification of the scales commences along the lateral lines and spreads from them over the rest of the body. The scaleless *Acanthodes beecheri* specimens therefore are immature, and it is possible that they represent the young of *A. marshi*. Specimens of intermediate size (Y. P. M. No. 2805, Eastman's 1902 pl. 5, fig. 3) support this interpretation. The fragmentary condition of the *A. marshi* specimens does not permit determination of the relative lengths of its pectoral and pelvic fin spines.

Of recent years there has been a tendency for American vertebrate paleontologists to accept the opinion of O. P. Hay (1902, p. 273) that *Acanthodes* Agassiz 1833 vol. 2, p. 3) is a synonym of *Acanthoessys* Agassiz 1832 (p. 149). The latter name was published without description, illustration, or indication of any sort, and must be regarded as a *nomen nudum* (cf. Neave, vol. 1, p. 15). *Acanthodes* was not preoccupied when described by Agassiz in July, 1833 (Jeannet, 1928, p. 102), so there is no reason to validate the earlier name on the basis of the 1833 reference and description. *Acanthodes* de Haan, a subgenus of *Cancer*



PLATE 11

Scales and fin spines of *Acanthodes marshi* Eastman. Los Angeles County Museum specimen no. 1353, from Mazon Creek, Illinois. Approximately natural size.

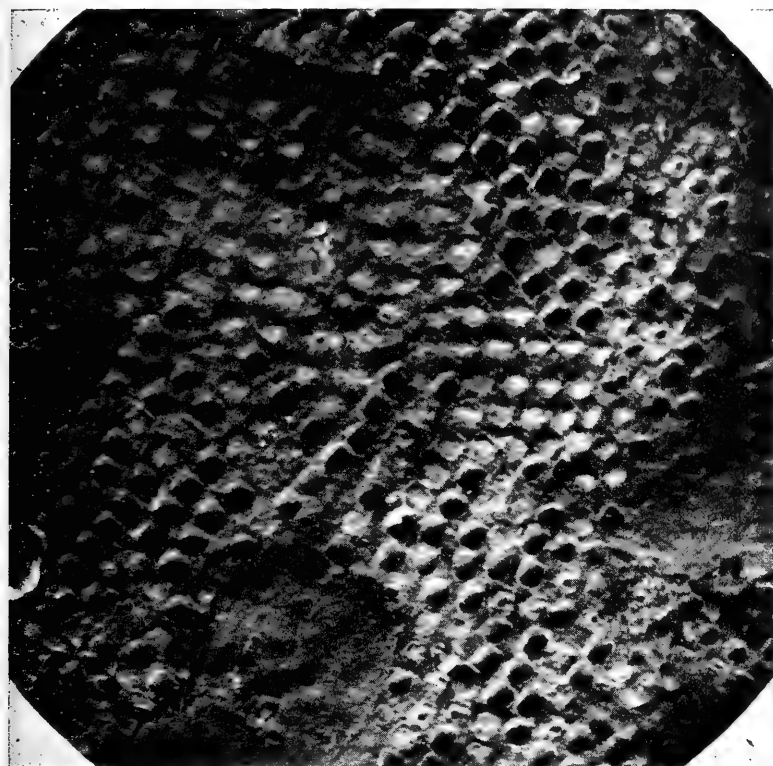


PLATE 12

Enlargement to show rhomboidal scales in portion of specimen illustrated in Plate 11. Approximately X 5.

(Crustacea) was also described in 1833, but cannot be given priority over *Acanthodes* Agassiz as the month of publication is unknown. At the 13th International Zoological Congress in Paris, 1948, it was agreed (Bull. Zool. Nomen, vol. 4, 224, iii, 1950) that works which contain a statement of the year but not the month and day of publication shall be deemed to have been published on the last day of the last month of that year. *Acanthodes*, therefore, is the valid name for the genus of placoderm fishes, its type being *A. bronni* Agassiz 1833.

Dr. Hildegard Howard, who kindly brought this specimen to my notice, pointed out the resemblance of these scales to the Linton, Ohio, fossil *Cercariomorphus parvisquamis* Cope. Moodie (1916, p. 138) notes that the largest scales of that specimen are 1 mm. in diameter, about the size of those of *Acanthodes marshi*.

Comparison of Moodie's Plate 24, fig. 2 with Eastman's illustration (1902, pl. 7, fig. 2) of *A. marshi* reveals the strong resemblance of this problematical form to acanthodian scales of which it may consist instead of calcified cartilage, as Romer (1930, p. 137) suggested.

I am indebted to Dr. John C. Armstrong of the American Museum of Natural History for advice on the nomenclatorial problem.

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A NEW BRITTLE STAR OF THE GENUS *ASTROPHIURA*
FROM SOUTHERN CALIFORNIA*

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The first *Astrophium* from Southern California was dredged in 1940 and additional specimens were dredged in 1941. These specimens were small and with limited available literature; they were presumed to be the young of *Astrophium permia*, Sladen (Ziesenhenné, 1941, p. 117). In 1949 some larger additional specimens were dredged with distinctive characteristics, upon which the basis for a new species could be described. A number of specimens were sent to Dr. Th. Mortensen, of Copenhagen, Denmark, who recommended the description of a new species.

OPHIOLEPIDIDÆ Ljungman 1867

ASTROPHIURA Sladen 1878

ASTROPHIURA MARIONÆ new species

Plate 13

Description.—Disk-body diameter, 5.8 mm.; diameter of disk, through distal edges of radial shields, 3.2 mm.; height of disk-body, 1.5 mm.; length of free arm beyond the margin of disk-body, 4 mm. The disk-body is pentagonal, convex upper surface and concave under surface, interbranchial margins almost straight. The upper arm segments are slightly elevated to form a noticeable ridge, radially, extending to the margin of the disk-body. Between the arm ridges the disk-body is slightly concave proximally, becoming straight distally at the interradial margins. The upper surface of the disk consists of 36 large, smooth, plates; including the radial shields. The upper side arm plates are fused, umbrella-like, to form the distal portion of the disk-body beyond the radial shields. The central plate is large, pentagonal, the margins are in contact interradially with five, smaller, rectangular basal plates, which are slightly broader than long. Distal to the basal plates is a second series of five, rectangular interradial plates of equal or slightly larger size. In one interradius this plate appears to be fused with a distal plate. The third series of five interradial plates are larger, rectangular, decidedly longer than wide; the lateral

*Contribution No. 54 of the Allan Hancock Foundation, University of Southern California, Los Angeles, California.

Fig. 1

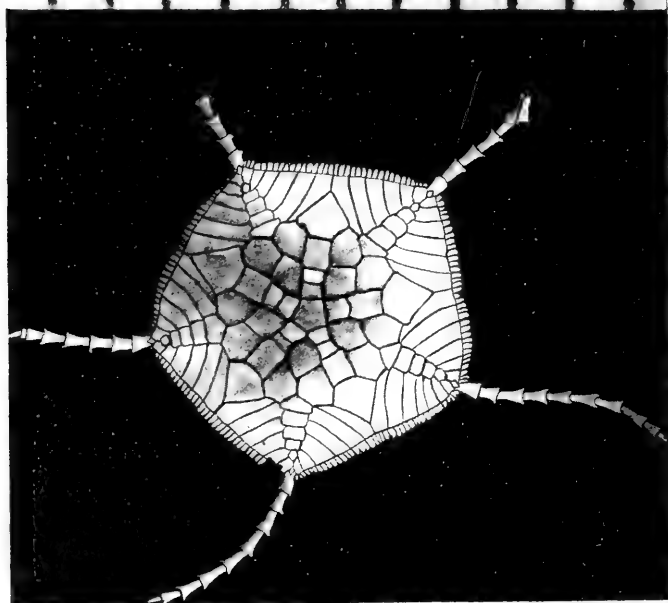
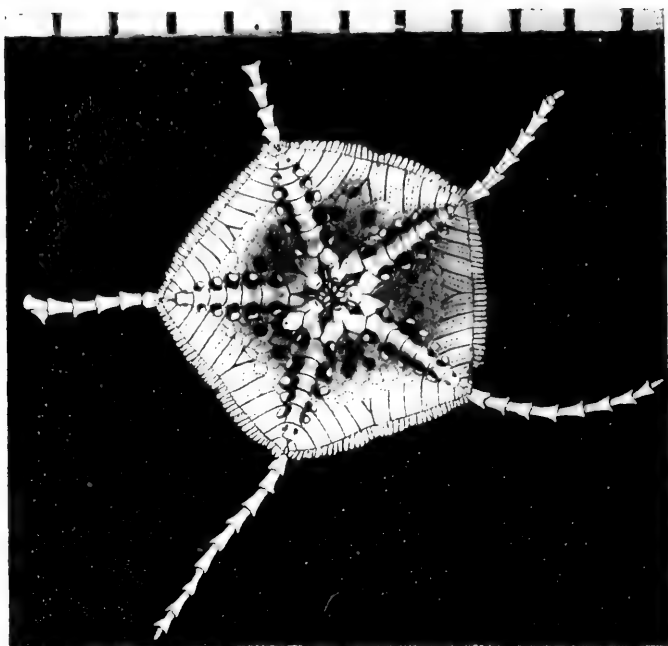


Fig. 2

PLATE 13

FIG. 1. Undersurface *Astrophium marionae* n. sp.
FIG. 2. Uppersurface *Astrophium marionae* n. sp.
Scale shown in millimeters.

margins are in contact with the interrarial proximal margins of the radial shields. The fourth interrarial series of five plates consist of exceedingly large, spear-shaped, irregularly pentagonal plates, equal to the radial shields in size. The three proximal margins are about one half the length of the distal lateral-margins. The proximal margin is in contact with the distal margin of the third series of interradians; proximal lateral margins are in contact with the radial shields. The distal lateral concave margins are in contact with the interrarial margins of the long, narrow, curved, modified side arm plates of the first proximal arm segment. Radially, and with the proximal angles barely in contact with the central plate are the five large radial plates. The radial plates are larger than the central plate, roughly diamond-shape, longer than wide, proximal margins longer than the distal margins, distal margins in contact with the radial shields. All disk plates are flat and smooth, lacking knobs or any other type of ornamentation.

The radial shields are large, exceeded in size by the fourth, distal-most interrarial spear-shaped plate; roughly hexagonal, longer than broad. Proximal angle is not quite a right angle; proximal apex of each pair of shields is separated by distal margins of the radial plate. The proximal margin is the longest, in contact with the radial and third interrarial plate, distal and distal-lateral margins short. Abradial-lateral margin is in contact with fourth series interrarial plate. Distal radial-lateral margin is in contact with first modified side arm plate and the distal margin is in contact with this second upper arm plate. Inner margins of the radial shields are in contact with each other for about two-fifths of their length. The distal portion of the radial shields cover the first upper arm plate. Beyond the disk proper, the remainder of the disk-body is composed of upper arm plates and modified side arm plates of the first six proximal arm segments. The side arm plates extend interradially and the outer margin of the first side arm plate from one radial contacts the outer margin of the side arm plate from an adjoining radial. Side arm plates two to six fuse in a like manner and the side arm plates become shorter in size gradually to the sixth, which is the shortest. The distal margin of each plate bears three, sometimes four, flat, papillæ, length about three times the diameter, fused laterally, to form a picket fence, their distal ends form the interrarial margins of the disk-body. There are thirty to thirty-eight spinelets in each interradius.

The second upper arm plate is the proximal upper arm plate visible beyond the radial shield. It is the largest of the upper arm plates, triangular in shape, broader than long, with an obtuse proximal angle. The third, fourth, and fifth upper arm plates are rectangular in shape. The third and fourth are broader than long

and the fifth is almost square, slightly broader than long. The sixth upper arm plate is small, diamond-shape, with acute distal and proximal angles, barely longer than wide. The sixth and seventh upper arm plates are separated by the side arm plates. The seventh upper arm plate is very small, triangular, and the last upper arm plate in the series.

The first side arm plate is curved, about five times as long as wide, outer proximal margin in contact with the large, spear-shaped, fourth series of interradial plates; outer distal margin in contact with corresponding side arm plate from adjoining arm for half the length of the margin. Second to sixth side arm plates are in complete contact with lateral margins of adjoining side arm plates. The side arm plates gradually become shorter to the sixth arm plate, which is only slightly longer than wide. A series of longitudinal ridges, parallel to lateral margins, is found on each side arm plate. The number of ridges conform with the number of spinelets on the distal margin of each plate. The free arms beyond the disk-body are delicate, slender, gradually tapering distally, consisting of ten abortive arm segments. The distal segment is reduced to a terminal spine, about three times the size of the arm spines. Both upper and under arm plates, tentacle pores, tentacle scales, and tube feet are lacking on the free arm segments. The first and second free arm segments are short, not quite twice as wide as long. Succeeding side arm plates become narrow and longer distally, length more than twice the width, trumpet-shape, wider distally, narrow proximally. Distal margin of each side arm plate bears one, small, short, peg-like spine, about twice as long as wide.

Oral shields are lacking. The madreporite plate is small, roughly oval-shaped, longer than wide, with the duct opening visible. Adoral plates not distinguishable under seventy-five power magnification. Oral plates relatively large, longer than wide, touching only at raised proximal ends, irregular-pentagonal, proximal median margin straight and short, interradial margin concave, more than twice the length of the proximal median margin. The distal margin is convex, in contact with the first under arm plate and first pair of tentacle pores. Two adradial margins almost straight, forming a wide obtuse angle. Jaws small, triangular, proximally pointing upward into the mouth and distally sloping away from the mouth, to contact outer margins of proximal raised ridge of oral plates. The jaw is separated from oral plates, along median margins, by a triangular, membrane-covered area. Each jaw bears at its apex a broad, flat, acute-tip, spear-shaped tooth, longer than the length of the jaw. The tooth points outward from the mouth. Both the tooth and the jaw are composed of semi-transparent plates. Oral papillæ two in number, proximal papilla is acute, flat, longer than wide, attached to the jaw, in contact with oral plate. The second papilla is blunt, edge

slightly concave, about twice as wide as long, attached to the oral plate.

Interbrachial spaces below are covered by a fine membrane that extends distally to the modified side arm plates of the disk-body. Imbedded in the membrane are large semi-transparent polygonal plates, about sixteen to twenty-two in each interradiar area. The under surface of the disk-body is concave. There are six pairs of large, conspicuous tentacle pores in each radius, proximal pair largest, each pair separated from each other by an elevated ridge on the under arm plates. Genital slits consist of two large circular openings in each interradius, about the size of the first tentacle pore, located interradially from the second tentacle pore, about the same distance as separates the first and second tentacle pores. In alcoholic transparent specimens, the dark gonads extend distally to the margin of the disk-body proper. Under arm plates are hour-glass-shaped, longer than wide, with the central portion constricted. The distal and proximal margins are elevated and enlarged to form a ridge, which separates the pairs of tentacle pores. The under arm plates become progressively smaller distally to the seventh under arm plate, at the margin of the disk-body, which is small, abortive, triangular in shape, and longer than wide. The free arms beyond the disk-body lack under arm plates. A large, single, broad, triangular tentacle scale, longer than wide, is located on the proximal, abradial margin of the tentacle pore. The succeeding tentacle scales gradually become smaller distally, to the sixth pore, where they are entirely lacking.

Color.—In life, still attached to the boulder, the upper arm plates and disk are straw-tan. Through the transparent disk the gonads form a star-shape of a darker color, brownish-black, with the edges of the gonads showing a tinge of brick red. Under surface of disk; the buccal cavity area is almost black, due to the mud content of the mouth. The oral plates are light gray. The jaws are light tan. The under arm plates are straw color. The tentacles are reddish-pink. The proximal interradius is dark brown, almost black. The gonads seen from the under side of the disk are brick red. The disk proper is darker than the fused side arm plates, which are straw colored. The free arms are straw color, semi-transparent. The color in alcohol is dark straw color; the contents of the buccal cavity dark brown and the outline of the tentacle pores and the tube feet light brown. The gonads are reddish brown. Specimens dried from alcohol are white, with the dried tube feet tan; gonads dark brown, and buccal cavity gray-black.

Type.—Holotype, A.H.F. No. E. 57; 82 paratypes.

Type locality.—Holotype and twenty-five paratypes from Station 1988-50, 230 fms. boulders, Bank, 6 miles east of Long Point,

Santa Catalina Island, California, August 12, 1950; one paratype from Station 1156-40, 230 to 380 fms. boulders, Bank, 6.5 miles east of Long Point, Santa Catalina Island, California, July 7, 1940; eight paratypes from Station 1306-41, 228 to 267 fms. boulders, 7 miles east of Long Point, Santa Catalina Island, California, May 3, 1941; eighteen paratypes, five now in the Zoological Museum, Copenhagen, Denmark, from Station 1862-49, 250 to 320 fms. boulders, Bank, 6 miles east of Long Point, Santa Catalina Island, California, July 1, 1949; eight paratypes from Station 1989-50, 330 fms. 4.5 miles E.N.E. of Avalon, Santa Catalina Island, California, August 12, 1950 and twenty-two paratypes from Station 1992-50, 230 to 250 fms. boulders, Bank, 6 miles east of Long Point, Santa Catalina Island, California, August 23, 1950.

Remarks.—The seventy-eight specimens in the collection from Southern California waters range in size from 1.6 mm. to 9.5 mm. in disk-body diameter. Only one specimen, with two central plates, differed from the symmetrical rosette arrangement of the thirty-six disk plates. Only two of the largest specimens had seven pairs of tentacle pores and the smallest had three pairs of tentacle pores. The majority had six pairs of tentacle pores. Only twenty-one specimens had three oral papillæ and the largest specimen had only two oral papillæ. The three specimens with disk-body diameter of less than two mm. had only one free arm segment. Only eleven specimens had more than one arm spine; in those, the two or three arm spines were on the first and second free arm segments. The arm spines were fused to form a comb or fence; probably a step in the development of forming the distal marginal fence as the side arm plates are incorporated into the disk-body. The genital slits were not observed in the smaller specimens. Only a few of the larger specimens had more than ten free arm segments, one had twelve and another had eleven. Little is known about the biology of this species as it lives attached to boulders, that have been dredged up from 230 to 380 fathoms of water off the east end of Santa Catalina Island, California. The larger boulders support the greater colonies, as high as seven specimens were taken from a fifty-pound boulder. The boulders are of basaltic rock, worn smooth, and with few marine organisms growing upon them. Since the dredge rarely fouls on the bottom and mud is always present in the hauls, it is presumed the boulders are scattered over the bottom and ocean currents keep the mud from covering the rocks. In their known natural environment the pressure varies from 612.7 to 1012.3 pounds per square inch. Once on deck under atmospheric pressure the specimens are sessile, and remain clinging to the rocks, even upon drying. No motion has been observed of the free arms of freshly dredged specimens. The concave under side makes a fine suction cup and the large tube feet assist the brittle star to hold tightly to the

smooth basaltic rocks. By clinging to the smooth rock, the animal is secure from being carried away by the strong currents. The disk-body is a strong shield of armor that prevents smaller natural enemies from attacking the tender under side, and permits the animal to feed within the protection of the disk-body. The feeding habits are unknown. The specimens may raise the disk-body and feed on particles carried by the ocean currents as barnacles and oysters feed. The disk-body suggests feeding habits similar to the abalones, limpets, and chitons that move over the surface of the rocks. Of all the specimens examined in the laboratory, only one had a recognized organism in the buccal cavity. The organism was a Helizoan covered with numerous outstanding glass spicules. Besides serving as a protective and feeding space, the concave under surface could also serve as a brood pouch, as is common to other brittle stars. To date, all specimens were dredged during the summer months and the young have not been observed. The three smallest specimens were fastened to the boulders independently, as were the larger forms.

The present species differs from *Astrophiura kawamurai* Matsumoto, from the Sagami Sea, Japan by:

1. Lacking the five infrabasal disk plates and having an additional five interradial plates.
2. The infrabasals, basals, and interradial plates are not elevated above the central, radials, and radial shields to form a system of ridges.
3. The radial plate is diamond-shaped, proximal angle in contact with the centrodorsal plate, while in *A. kawamurai* the radial is definitely pentagonal and the proximal margin is in contact with the infrabasal plate.
4. The modified side arm plates of the disk-body are longer, narrower and curved, occupying a greater portion of the disk-body, normally six and rarely seven segments within the disk-body, compared to eight or nine in *A. kawamurai*.
5. The radial shields are hexagonal, straight margins, longer than wide, median margins in full contact with each other for two-fifths of their length. The radial shields in *A. kawamurai* are rounded-triangular, curved margins, hardly touching each other.
6. The fourth large interradial spear-shaped plate is as wide as long. In *A. kawamurai* this plate is longer than wide and the latero-distal margins are concave, more than twice the length of the other margins.
7. The disk-body is definitely raised, convex on the upper and concave on the under surfaces. Not at all flat as in *A. kawamurai*.
8. Oral papillae two, rarely three to a side as compared to four or five in *A. kawamurai*.

9. Because of the longer side arm plates within the disk-body, the under surface area covered with the fine scale-imbedded membrane is smaller.

10. In all but the smallest specimens the genital pores are visible.

Astrophium marionae differs from *Astrophium cavellae*, Koehler, from the Cape of Good Hope, Atlantic Ocean, by:

1. The absence of a central cluster of spinelets, bosses, knobs or any other type or ornamentation on the primary disk plates.

2. The disk area being smaller and the fused side arm plates occupying a greater area of the disk-body. In *A. cavellae* the large fourth interradial plate almost reaches the disk-body distal margin and a smaller portion of the under side arm plates are exposed.

3. The infrabasal plate is lacking between the centrodorsal and radial plate and there are four series of interradials as compared to only three in *A. cavellae*.

4. The centrodorsal and radial plates are larger than the surrounding plates. In *A. cavellae* the centrodorsal and the surrounding plates are of about equal size.

5. The radial plate is diamond-shaped while in *A. cavellae* it is pentagonal.

6. The basal or first interradial is rectangular, while in *A. cavellae* it is pentagonal.

7. The madreporite plate is roughly oval-shape while in *A. cavellae* it is pentagonal.

8. Oral papillae in *A. cavellae* are long, narrow and acute-pointed, three or four to each side.

9. Free arms beyond disk-body lack upper and under arm plates.

10. Radial shields in *A. cavellae* are barely touching each other.

The present species differs from *Astrophium permira*, Sladen, from Madagascar in the Indian Ocean by:

1. The regular, symmetrical rosette arrangement of the 36 disk plates.

2. Absence of a central boss, knobs or other ornamentation on the primary disk plates.

3. There is a greater area of exposed side arm plates, both upper and under surfaces of the disk-body.

4. Absence of upper or under plates on the free arm segments beyond disk-body.

5. The pentagonal centrodorsal and radial plates are larger.

6. The absence of the infrabasal disk plates.

7. The symmetrical upper arm plates are smaller and narrower.

The present species is the first to be taken from waters of the North American Continent and the first from Eastern Pacific waters, which geographically separates *Astrophphiura marionæ* from the above named species.

It gives me great pleasure to name this species for Mrs. Marion M. Hancock, wife of Captain G. Allan Hancock, Director of the Allan Hancock Foundation, the University of Southern California.

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FOSSIL ARTHROPODS FROM ONYX-MARBLE

4. HOT CALCAREOUS WATERS KILLING INSECTS

By W. DWIGHT PIERCE

The article by John Hilton quoted in Note 1 of this series, suggested to the writer that perhaps the well now called Hot Mineral, in Imperial County, California, might furnish some ideas as to how insects become incorporated in onyx-marble.

On November 10, 1950, Dr. Raymond Jenness Barber and the writer visited Hot Mineral which is located near the All-American Canal Road, 37 miles southeast of Mecca, 4.5 miles easterly from Highway No. 111, turning in at the railroad stop Frink.

This well was drilled in 1939 under direction of the United States Reclamation Bureau. An official sign posted at the well states that it is 305 feet deep, with a 14 inch casing. A concrete block holds the pressure. The water flows at two cubic feet per second. It contains 4000 parts per million of dissolved salts, with CO₂ gas.

At the orifice the official temperature is 174°F. At five feet our measurement was 170°F. The mineral crystallizes out, forming pools of decreasing temperatures as the water flows down the slope. At about 75 feet from the orifice the temperature at the time of our visit was 158°F; at 150 feet it was 105°F; at about 300 feet it was 82°F; while the atmospheric temperature was 78°F.

The surface crystals are colored pink, yellow, blue, green, dark maroon, light brown, pure white, but mostly buff. Some of the colors are due to algae living in the water. There are many little craters in the crystal bottom of the pools, caused by escaping gas.

Any object falling into the water becomes the center of crystallization. Thus a tiny insect may be the nucleus for a beautiful oval or circular floating disc, which grows concentrically, and under which other crystals form until the weight causes it to fall to the bottom. Stems become beautifully encrusted and the mineral replaces or modifies the tissues.

As expected we found that many insects are being killed by the hot water. They drift in the swiftly flowing water to the margins of the pools, and each becomes the center of crystal growth. Sometimes a thin paper-thick layer of crystals contains many tiny midges and other small insects. In all 132 specimens of arthropoda were found in the water in a short time. These represent Araneida, Odonata (Zygoptera and Anisoptera), Ephemerida, Psylloptera, Hemiptera (Corixidae and Notonectidae), Coleoptera (Hydrophilidae, Staphylinidae, and Psallidiidae), Lepidoptera (Geometridae), Hymenoptera (Vespidae), and Diptera (Chironomidae, etc); all winged except one spider.

The crystallization on these specimens is similar to that formed on the millipede *Parajulus lasti* Pierce, which was found

among calcite and quartz crystals in volcanic lava at 900 feet depth in a well at Oxnard, California (See Bull. So. Cal. Acad. Sci. 44(1):2).

As hot water of 110° will kill almost any insect, it is probable that the bottom crust contains multitudes of them. These encrusted insects fall to the bottom as the crystal mass becomes too heavy to float, and there they are incorporated in the homologous mass of crystals, which in due time under proper temperature and pressure will become onyx-marble.

Thus we can say that the finding of winged insects in onyx-marble will indicate that they were caught in open flowing calcareous waters.

Word has been received that insect wings occur in the Mexican onyx-marble from El Marmol, Baja California. This deposit is formed by a hot mineral well on the side of a volcano, and the waters flowed into a depression where a solid deposit of onyx-marble is being mined.

Hot Mineral is on or near the San Andreas Fault.

5. FURTHER MATERIAL FROM THE BONNER ONYX-MARBLE QUARRY

In addition to the articles cited in part 1, Dr. Ralph V. Chamberlin described in 1949 (Trans. San Diego Soc. Nat. Hist. 11(7): 117-120, pl. 7) "A new fossil Chilopod from the Late Cenozoic." This specimen was classified in Order Geophilida, Geophilidae new genus *Calciphilus*, new species *C. abbotti*, a centipede with approximately 115 pairs of legs. The specimen was calculated to be 115 mm. long.

Clarifying the onyx-marble formation, Dr. Edwin D. McKee in 1946 published the article "Onyx marble in Northern Arizona" (Plateau, a Quarterly of Northern Arizona Society of Science and Art. Museum of Northern Arizona, Flagstaff 19(1):9-12, 4 figs.)

"The calcite has been deposited by water in cracks, such as joints and faults, and between sedimentary beds in Supai, Kaibab, and Moenkopi formations. At the Bonner Quarry southwest of Ashfork, the onyx-marble occurs in the Supai formation (Permian) which in the vicinity of the quarry consists of red shaly siltstone that has been dragged down along a large, nearly vertical fault. Movement of the fault has totaled some hundreds of feet, and has resulted in bending and shattering the rock in this area, thus allowing ample opportunity for water to penetrate and form onyx-marble. Deposition of the onyx-marble is largely, though not entirely along bedding planes in the red siltstone. Series of brown to honey yellow layers of calcite have formed, with each layer separated by a thin film of red detrital sediment that probably was dust accumulated during the time of non-deposition. The calcite layers have a tendency to thicken and dome upward

toward their centers and individual layers commonly are progressively thinner and less massive toward the top of the series, ranging from four to five feet down to one to two inches. In many places the thin upper beds have been shattered since deposition."

"The fault is older than the basaltic lava on the adjoining hill, which it does not disturb."

Since writing the first three parts the writer has seen a total of 15 polished slabs of onyx-marble from the collection of Mr. J. W. Fisher of San Diego, President of the Southwest Onyx and Marble Company, and these contain 30 visible specimens, although some are too deep for study.

With the exception of one specimen, which may be wrongly interpreted, all of the species would normally be found in the soil or in damp crevices in the rocks, except perhaps at night, and it could be explained that they were caught by the seeping of the calcareous waters into their hiding places. This one doubtful specimen has the general form of a young walking stick, but with a longer head than usual, and it would not be unexpected if it should hide during the heat of the day in a crevice.

Of the total of 25 which can be ordinarily classified, 15 specimens are pedipalps, 1 is a millipede, 9 are insects. The insects belong to the Orders Dicellura, Rhabdura, Archæognatha, Zygentoma, and Phasmida. All in all it is a very primitive assemblage, without a single winged insect. Adding to these the specimens described by Petrunkevitch and Chamberlin, the total is 17 Pedipalpi, 1 Chilopoda, 1 Diplopoda, 9 Insecta.

Another characteristic of the entire series is that they have been boiled out by the hot calcareous water. In some specimens the dissipation of the body contents into the surrounding liquid is very evident. When viewed with a strong light, showing through, it is apparent that the remains are principally skeletal, and very much distended.

Only seven specimens (4 insects, 2 pedipalps, and the millipede) were uninjured by the cutting and polishing. In addition there are several clumps of legs unassociated with bodies.

Mr. Louis Athon of the Los Angeles County Museum staff has made excellent photographs of these difficult subjects, which are valuable to supplement the records. These illustrate the graining of the onyx-marble, the diffusion of the body contents, and the injury resulting from cutting. The cutting was purely a commercial proposition, and the finding of the fossils was incidental.

Due to the condition of the material very little descriptive detail can be given, but drawings have been made to show such details as are clear and of value in locating the species.

The insects belong to groups seldom if ever found fossil, because of their delicate nature. This makes them very important. In fact few entomologists have taken the trouble to collect these rare earth-living insects.

6. A PERSONAL VISIT TO BONNER QUARRY

With Dr. Barber the writer visited the quarry from which the fossil arthropods were obtained. It is difficult of access, due to the very poor roads through a rocky juniper forest in the Kaibab National Forest of Yavapai Co., Arizona. It is located 17 miles southwest of Ash Fork in the NW $\frac{1}{4}$ of Section 21, Township 20 N (the South boundary of T 20 N is at $35^{\circ} 00'$ No. Lat.), Range 3 W (the East boundary of R 3 W is 112° W. Long.). Measured by aneroid barometer and checked with topographic sheets, the altitude is 5329 feet.

The formation containing the onyx-marble is Middle Permian, Supai formation, which has been faulted. Considerable onyx-marble is still in position, but the quarry was abandoned because of a serious cave-in.

The siltstone strata are inclined at an angle of 31° from the horizontal, in the direction of 10° East of true North. A layer of onyx-marble from 1 foot to 2.5 feet thick, interbedded at the same inclination, forms the roof of the open cavern, which extends to the depth of about 25 feet, with a width of about 15 feet.

Great piles of onyx-marble blocks lie around the quarry, where they were left by the operators. The material is so hard that it cannot be easily broken, and it is impossible to determine presence of insects in the rock without cutting and polishing.

We found evidences that this onyx-marble was formed by the infiltration upward and laterally in cracks and crevices, of hot, mineral-impregnated waters. In places where the crevices were not completely filled we found surface incrustations exactly similar to those at Hot Mineral. We found where hot waters had forced their way upward through the mushy top layer and flowed out over it to form new layers, in exactly the same manner as is now occurring at Hot Mineral. Pipes and gas tubes are still evident in the hard onyx-marble, and in one specimen the protruding mineral waters formed a bulbous mass of onyx-marble three inches in diameter protruding into the open, above a relatively smooth surface of the ancient rock-enclosed pool.

Several of the specimens show inclusions of angular fragments of the original red stone which indicate that the openings had probably been caused by movement and fracturing of the rock along a fault zone. This fault undoubtedly determined the position of the cañon in which the onyx-marble is now found, and caused the Permian siltstone on the Northeast side, and the Devonian limestone on the southwest side of the cañon, now to exist at the same elevation.

All of the insects and the other arthropods so far found in this onyx-marble are typical of arid-region rock-dwelling life, except the one phasmid, which might hide in the rocky crevices in the heat of day.

The evidence is that they were caught in the cracks by the

hot water and instantly killed, and their body contents oozed into the surrounding waters.

Dr. McKee (1946) states in his article that the arthropod fossils "Probably represent a time when there was more water in the region than today to account for the extensive deposits in an area of present active erosion."

But perhaps a different interpretation can be given, considering Hot Mineral, El Marmol, and Bonner Quarry as parallel. The two first cases are in arid regions into which hot subterranean waters are being forced upward. At Hot Mineral the influence of this water is not shown outside of the area wet by the water, which in a few hundred yards has all sunk into the sandy soil or evaporated. So it appears that at Bonner Quarry hot mineral waters from below were forced up into the rocks and caught typically wingless, desert-rock-inhabiting creatures.

This new interpretation would merely push the time back to a period when subterranean volcanic activity was greater than now.

As to the age of the deposit, Dr. Barber wrote for our joint report: "the folding and faulting that caused the openings into which the calcareous waters flowed to form onyx-marble, might well have occurred during Mesozoic time when there was such widespread crustal unrest, resulting in the elevation of the Sierra Nevada and Rocky Mountains. The source of the hot calcareous waters, whether deep seated or not would probably have been associated with volcanic intrusions and extrusions, which occurred in all that part of the country during Tertiary times. The age of the onyx-marble may therefore be estimated at as much as fifty million years."

Dr. Barber's estimate would bring the fossils back to Eocene times. Dr. Rene Engel on examining the onyx-marble told the writer he was perfectly safe to put the age at least as early as the Miocene. So the age of the fossils lies between 12 and 50 million years. Dr. McKee places the onyx-marble as post-faulting, but earlier than the basaltic lava of the nearby hills.

The primitive nature of the fossils favors a considerable age. Probably some other factor will be found to give us a more accurate estimate of the period in which this deposit occurred.

7. THE FOSSIL PEDIPALPI FROM BONNER QUARRY

As was stated in part 5, the Pedipalpi are in the majority among the specimens found in the onyx-marble. Although most of them are defective in one way or another, it appears that the series includes at least three species, if reliance is to be placed on sternal characters.

The systematic position of these creatures is unquestionably in the Pedipalpi Latreille 1806, Uropygi Thorell 1882, because the cephalothorax is longer than broad, with almost parallel sides.

Kræpelin in 1899 (*Das Tierreich*, lief. 8:201-251, figs. 64-94) divided the Uropygi into two families, Thelyphonidæ Lucas 1835 with cephalothorax undivided, and cauda segmented; and Schiz-onotidæ Thorell 1888, with cephalothorax divided between second and third pairs of legs; cauda unsegmented.

Petrunkévitch 1945 following Hansen and Soerensen 1905 altered Schiz-onotidæ to Schizomidæ, and raised it to the ordinal rank as Schizomida, adding the family Calcitronidæ for his fossil insect, with three caudal segments. The writer does not feel that the creation of an order is warranted, but would still consider Pedipalpi as an order, Uropygi as a suborder, and create Schiz-omoidea and Thelyphonoidea as new superfamilies, in line with modern classification.

Even then it becomes difficult to classify these fossils, because we cannot see all necessary characters, and those we can see appear to be intermediate between the two groups. The solution for the present is to simplify group characters and place a different stress upon them.

- 1a. Caudal appendage long, many-segmented; tarsal flagellum of first pair of legs 9-segmented; cephalothorax undivided.....
THELYPHONOIDEA new superfamily.....
THELYPHONIDÆ Lucas 1835
 This group contains at least 10 genera.
- 1b. Caudal appendage short, with one or few segments.....
SCHIZOMOIDEA new superfamily.....2.
- 2a. Caudal appendage short, with few segments; fourth trochanter longer than coxa; fossil species.....
CALCITRONIDÆ Petrunkevitch 1945.....3.
- 2b. Caudal appendage short, unsegmented, or with a thick end knob; fourth trochanter shorter than coxa.....
SCHIZOMIDÆ Hansen and Soerensen 1905....4.
- 3a. Caudal appendage 7-segmented; tarsal flagellum of first pair of legs with metatarsus and three tarsal joints; second, third, and fourth pairs with metatarsus and two tarsal joints; second and third coxæ very narrowly separated, almost contiguous, but fourth coxæ well separated. ONYCHOTHELYPHONUS Pierce 1950.
- b. Caudal appendage 3-segmented; tarsal flagellum of first pair of legs with metatarsus and seven tarsal joints; second pair with five tarsal joints; third and fourth pairs with four tarsal joints; second and third coxæ very narrowly separated; fourth coxæ contiguous
CALCITRO Petrunkevitch 1945.
- 4a. Fossil species. Second, third and fourth coxæ broadly separated; pedipalpi simple, untoothed....CALCOSCHIZOMUS new genus.

- b. Living species; tarsal flagellum of first pair of legs with metatarsus and seven tarsal joints; second, third and fourth legs with three tarsal joints; pedipalpi toothed on one or more segments.....SCHIZOMUS Cook 1899.

(*Schizonotus* Thorell 1888 preoccupied)

.....TRITHYREUS Kræpelin 1899.

(*Tripeltis* Thorell 1889 preoccupied).

.....STENOCHRUS Chamberlin 1922.

The difficulty in classification of the fossils lies in the disintegration that has obscured characters. In two specimens, BQ 8 and BQ 11, assigned to *Calcitro fisheri* Petrunkevitch, the cephalothorax is definitely transversely divided between the second and third pairs of legs. In no other specimen is such a division indicated. Specimen BQ 15, measuring 4.0 mm. in length, may be *Calcitro fisheri*, but the dorsal view (Figure 5) does not show any division of the cephalothorax, and the cauda seems undivided, as in *Schizomus*.

The division of the tarsi into segments cannot be definitely determined in BQ 20, which is named *Calcoschizomus latisternum*.

In size, the three species before the writer range as follows: *Onychothelyphonus bonneri* 3.64 mm.; *Calcitro fisheri* 4.5 mm. (BQ 8), 4.4 mm. (BQ 13), 4.75 mm. (BQ 11), 4.8 mm. (BQ 17), the type measured 4.4 mm.; and the paratype 4.0 mm.; and *Calcoschizomus latisternum* 14 mm. Two undeterminable specimens should be mentioned: BQ 14 with front end missing is 6.16 mm. long; and BQ 27 in side view, the pedipalpi missing, broken between third and fourth pairs of legs, is 13 mm. long.

In addition to all of these specimens are three tiny ones too deep for exact characterization, but unquestionably pedipalpid. They may be young. No division of thorax is evident, nor is any cauda. They measure 2.0, 2.6, and 3.0 mm. in length. Perhaps at a later date the plaques can be polished down to make description possible.

Mr. Louis Athon, Los Angeles County Museum photographer, has photographed these difficult subjects, and on plate 1 are represented the three named species. Figure 3 is of value only to show the crystalline nature of the onyx-marble, and the difficulty of determining characters. Figure 4 shows the disintegration of the tissues which took place in the hot calcareous water before final crystallization.

The sternum gives the best character for differentiating the species at hand. Petrunkevitch figured *Calcitro fisheri* with fourth coxæ in contact, second and third narrowly separated. The specimen BQ 8 fits the drawings and description in every respect except that the fourth coxæ are as widely separated as the second, and not in contact (Figure 6).

In Article 3, *Onychothelyphonus bonneri* was illustrated, and it will be noted that the fourth coxæ are widely separated, while second and third are very narrowly separated.

The new species now to be described differs from both by having all coxæ widely separated, as shown in Figure 7.

CALCOSCHIZOMUS, new genus.

Pedipalps of the family Schizomidae; with simple, untoothed pedipalpi; cauda simple unsegmented; all coxæ well separated; fourth trochanters shorter than the coxæ.

CALCOSCHIZOMUS LATISTERNUM, new species. (Figures 4, 7)

Type of the genus. Fossil in onyx-marble from Bonner Quarry, Kaibab National Forest, Yavapai County, Arizona. Found by J. W. Fisher.

Length of body 14 mm. The left pedipalp is distinctly outlined, without tooth or prominence, but segmentation is not clear. A very hairy process from near base of this pedipalp is probably the chelicera. Between the front coxæ there is a round elevation. The coxæ are all well separated; the trochanters all shorter than the coxæ. On account of the dense clouding around the legs, it is not possible to accurately define the legs.

8. A FOSSIL MILLIPEDE FROM BONNER QUARRY

A beautiful specimen of millipede is on circular slab No. 10. The front portion was separated from the remainder of the body, a short distance. In the slab the hind end is too deep for diagnostic characters.

DIPLOPODA Blainville & Gervais 1844

JULOIDEA Attems 1898 (*Iuloidea* Silvestri 1896)

PARAJULIDÆ Attems 1909

PARAJULUS Humbert & Saussure 1869

PARAJULUS ONYCHIS, new species. (Figures 8, 9, and Plate 16)

Fossil in onyx-marble, Bonner Quarry, Kaibab National Forest, Yavapai County, Arizona. Found by J. W. Fisher.

Length of curled specimen 18 mm.; approximate length of body 39.4 mm. Number of segments: head, 4 thoracic, 54 abdominal, 1 terminal,—total 60 segments. Number of legs: 3 thoracic pairs (none on third segment), 108 abdominal pairs,—total 111 pairs. One 5-jointed antenna has been separated from head. The left first thoracic leg (Figure 8) is greatly enlarged and five-jointed, but a detached claw may belong to it, making it 6-jointed. The abdominal legs (Figure 9), two pairs to a segment, are 6-jointed.

Fig. 1



Fig. 2



Fig. 3



Fig. 4

PLATE 14

Figure 1. *Calcitro fisheri* Petrunkevitch (Specimen BQ 15), length 4 mm.

Figure 2. *Calcitro fisheri* Petrunkevitch (Specimen BQ 13), length 4.4 mm.

Figure 3. *Onychothelyphonus bonneri* Pierce (Specimen BQ 1), length 3.64 mm.

Figure 4. *Calcoschizomus latisternum* Pierce (Specimen BQ 20), length 14 mm.

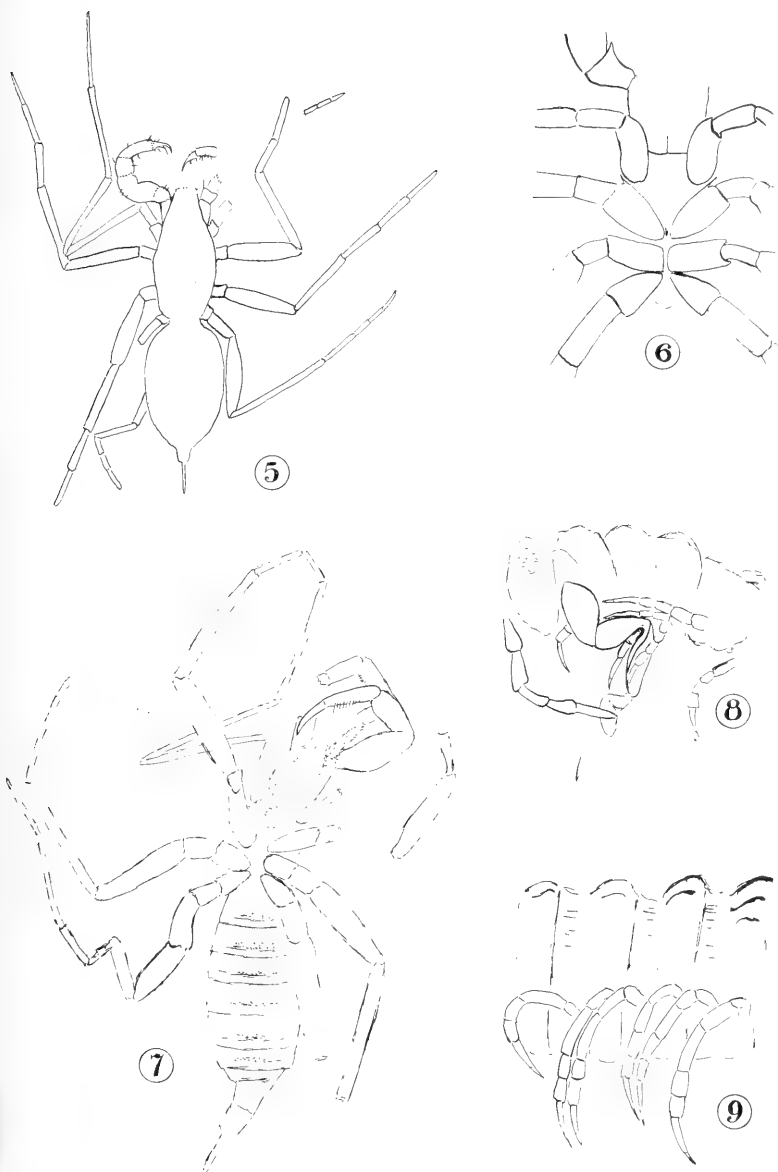


PLATE 15

Figure 5. *Calcitro fisheri* Petrunkevitch (Specimen BQ 15), detail.

Figure 6. *Calcitro fisheri* Petrunkevitch (Specimen BQ 8), detail of sternum.

Figure 7. *Calcoschizomus latisternum* Pierce, detail study.

Figure 8. *Parajulus onychis* Pierce, detail of anterior portion.

Figure 9. *Parajulus onychis* Pierce, detail of three abdominal segments.



PLATE 16

Parajulus onychis Pierce (Specimen BQ 19), length of specimen 18 mm.; uncoiled length about 39.4 mm.

9. FOSSIL PRIMITIVE INSECTS FROM ONYX-MARBLE

The newer material lent by Mr. J. W. Fisher contains a total of seven primitive insects, in the orders Archæognatha, Zygentoma, Dicellura, Rhabdura, and Phasmida.

Outside of Baltic amber no fossils in the first four orders are known, and these insects are the first to be described from onyx-marble. In Article No. 3 in this series *Onychojapyx schmidtii*, in the Japygidæ, was described. Four more thysanurans are now to be added.

ARCHÆOGNATHA Boerner 1904

MACHILIDÆ Grassi 1888

Although somewhat disintegrated by the calcareous liquid the ordinal identity of the first specimen is certain. The Zygentoma, or running silver fish have styli on abdominal sternites 7 to 9 or 8 to 9; while the Archæognatha, or jumping silver fish have styli

on segments 2 to 9. The posterior portion of the abdomen was cut off, but 3 styli, on the second and third segments remain. Characteristic of the Machilidæ are the long maxillary palpi and the thick labial palpi seen in this specimen.

This specimen (BQ 7) is white, and dorso-ventrally flattened, rather than laterally compressed. It has no indication of scales on the body.

ONYCHOMACHILIS, new genus

Although 9 genera of Machilidæ are now living in the Americas this species seems even more primitive, and has therefore been set off as a new genus, possibly to be assigned to the Meinertellinæ of Wygodzinski.

Antennal joints about twice as long as wide; maxillary palpal joints elongate. labial palpi stout. Tarsal joints 1/2 and 3 elongate (the diagonal separation of 1 and 2 cannot be seen); claws of posterior tarsi large and spreading outward. Styli of second segment with a strong spine at apical third posteriorly, appearing almost as a cleavage.

ONYCHOMACHILIS FISHERI, new species. (Figures 12, 15)

Type of genus.

Length of fragment 7 mm. from tip of antenna; of body portion 5.5 mm. Color white; no scales present (they may have been deciduous). The outlines in Figure 15 must not be considered as exact, because of the state of preservation. A living insect might have looked quite differently.

The antennæ are both broken, but the left one is longer. The last joint of the left maxillary palpus is missing. Anterior left leg has the third tarsal joint lying near by. The tarsus of the right leg is missing. Middle left leg is entire, but only the femur remains of the right leg. The posterior legs have been twisted, so that the femur of the left leg appears behind the right anterior leg; and the right posterior leg has swung over and appears on the left side, all parts present; the last tarsal joint turned upward presents the claws plainly.

ZYGENTOMA Börner 1904

LEPISMATIDÆ Escherich (*Lepismidæ* Lubbock 1873)

ONYCHOLEPISMA, new genus

A primitive silver fish, fossil in onyx-marble.

ONYCHOLEPISMA ARIZONÆ, new species (Figure 14)

Type of genus.

Fossil in onyx-marble, from Bonner Quarry, Kaibab National

Fig. 11

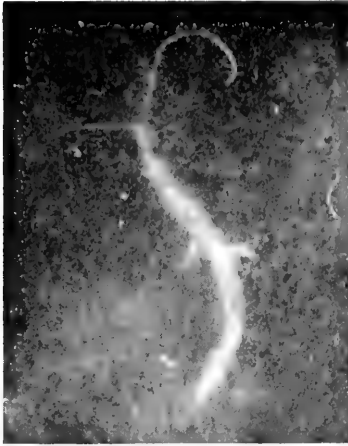


Fig. 12



Fig. 13



Fig. 14

PLATE 17

Figure 11. *Onychocampodea onychis* Pierce (Specimen BQ 26), length of body 10.56 mm.

Figure 12. *Onychomachilis fisheri* Pierce (Specimen BQ 7), length of body 5.28 mm.

Figure 13. *Calcibacunculus tenuis* Pierce (Specimen BQ 25), length of specimen 8.8 mm.

Figure 14. *Onycholepisma arizonae* Pierce (Specimen BQ 28), length of body 8.84 mm.

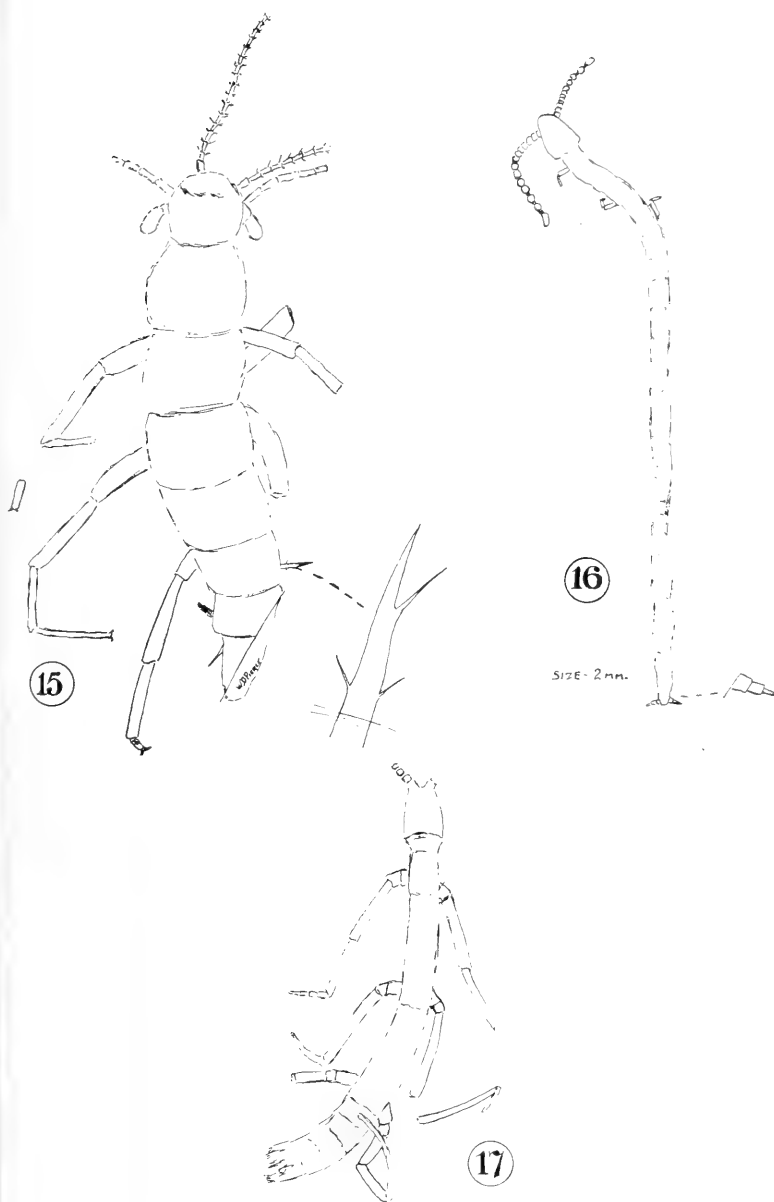


PLATE 18

Figure 15. *Onychomachilis fisheri* Pierce, detail study.

Figure 16. *Plioprojapyx primitivus* Pierce (Specimen BQ 29), length 2 mm

Figure 17. *Calcibacunculus tenuis* Pierce, detail study.

Photographs by Louis Athon; drawings by the author.

Forest Yavapai County, Arizona. Found by J. W. Fisher. Specimen BQ 28.

This insect is not well defined but has long antennæ, long caudal filaments, and two shorter caudal cerci.

Body length 8.84 mm., antennæ 3.00 mm., caudal filaments 3.2 mm., width of head 0.56 mm., pro-, meso-, and metanotum 0.80 mm., abdomen at base 0.60 mm., at apex 0.40 mm.

One specimen (BQ 21) is too deep for study, but the scaly surface is evident at one point.

Specimen BQ 10, too deep for study, is either a Machilid or a Lepismatid.

RHABDURA (Silvestri) Handlirsch 1903

CAMPODEIDÆ Westwood 1873

ONYCHOCAMPODEA, new genus

ONYCHOCAMPODEA ONYCHIS, new species (Figure 11)

Type of genus. Specimen BQ 26, fossil in onyx-marble, Bonner Quarry, Kaibab National Forest, Yavapai County, Arizona. Discovered by J. W. Fisher.

Length of body 10.56 mm., antennæ 6.40 mm.

The caudal filaments are not visible.

This is much larger than any known modern Campodeid, but unfortunately none of its characters is describable.

DICELLURA (Haliday) Cook 1896

PROJAPYGIDÆ, Cook 1896

PLIOPROJAPYX, new genus

PLIOPROJAPYX PRIMITIVUS, new species (Figure 16)

Type of genus. Specimen BQ 29, fossil in onyx-marble, Bonner Quarry, Kaibab National Forest, Yavapai County, Arizona. Discovered by J. W. Fisher.

Length of the greatly distended body 2 mm.; head 0.16 mm. long, 0.12 mm. wide. The antennæ seem to be 13-jointed. The caudal cerci extend sideways and are 3-segmented.

PHASMIDA Leach 1815

BACUNCULIDÆ Brunner 1893

CALCIBACUNCULUS, new genus

CALCIBACUNCULUS TENUIS, new species (Figures 13, 17)

Type of genus. Specimen BQ 25, fossil in onyx-marble, Bonner Quarry, Kaibab National Forest, Yavapai County, Arizona, discovered by J. W. Fisher.

Specimen measures 8.80 mm.; head 1.28 mm. long, 0.88 mm. wide; prothorax 0.88 mm. long, 0.80 mm. wide; mesothorax 2.32 mm. long, 0.80 mm. wide; metathorax 2.00 long, 0.80 mm. wide. The posterior part of the abdomen is cut off.

This is either a young walking stick, or an unknown type of primitive insect.

The long head, sharply narrowed behind, with no evidence of eyes, may be considered as the differentiating generic character. Only the base of the antennæ remains. Since this species occurred in the rocks it was very likely a blind insect.

The long thoracic segments, with legs attached posteriorly on each, and the transverse coxæ give this insect a very striking appearance.

The types described in this article have been deposited by Mr. J. W. Fisher, President of the Southwest Onyx and Marble Company of San Diego, in the Palaeontomological Collections of the Los Angeles County Museum. Paleontologists will be grateful for his far sighted generosity.



GEOMETRID NOTES

By JOHN L. SPERRY
Riverside, California

CHLOROSEA NEVADARIA Packard

During the last week of July 1949, which the author spent in hospital at Enterprise, Oregon with his leg in a cast, Mrs. Sperry took, at light, at the Lazy T Ranch on the north slope of Chief Joseph Mt., six specimens of this rarity, all females, in excellent, fresh condition. Examination of these adds another character to the *nevadaria* description, overlooked in the examination of worn specimens. Dorsally on the second and third abdominal segments appear small whitish, wedge shaped, triangular spots pointing toward the thorax with the faintest or orange-yellow tinges about the apices. This is scarcely discernible except under magnification.

The genus *Chlorochlamys* Hulst is badly in need of revision, but it will be necessary to examine types of the species of Prout, Walker and Swett before this can be adequately done. However, thanks to the kindness and careful comparisons of and by Mr. D. S. Fletcher of the British Museum staff and Dr. Frederick Rindge of the American Museum of Natural History the author has been enabled to do a little of the preliminary work at this time. It seems especially wise to clarify the status of the species forming the *volantaria-masonaria-martinaria* group and to attach a name to the common Southwestern desert species, heretofore misidentified as *chloroleucaria* Gn. or *volantaria* Pears, by several entomologists, including the author.

The first mentioned group is characterized by larger size (20 to 24 mm.) squamous vestiture with a tendency to mottling of the dull olive-green ground color of the wings and waved t.a. and t.p. lines on the primaries.

Viridipallens Hulst probably heads the group and it is more than probable as Prout suggests (Seitz, VIII, 62) that *volantaria* Pears. is synonymous.

Dr. Rindge, having been allowed at long last to make a slide of the Colorado type, writes that all characters seem to be identical with those of a paratype male of *volantaria* with the exception that the aedeagus of *volantaria* appears a little longer and a little thinner than that of *viridipallens*, the specimens being of equal size. The associated female is from Arizona and is probably better associated with *volantaria*.

Volantaria Pears. and *martinaria* Sperry are very close insofar as their maculation is concerned, *volantaria* is larger and the palpi especially in the female, are much longer than in *martinaria*. Dr. Rindge writes that, if he has the sexes properly associated, *volantaria* has a fairly large plate in the female genitalia, the plate in *martinaria* is smaller with two smaller sclerotized pieces, posterior and lateral. *Masonaria* Schaus from Mexico may be separated from the other two by its larger size and the presence of dorsal abdominal spots, which are lacking in the other species. In the light of this information, the Allotype of the author's species *martinaria* must be placed under *volantaria* Pears. in the Sperry collection and a new Allotype (Madera Canyon, Santa Rita Mts., Ariz., July 31, 1947, J. A. Comstock and Lloyd Martin, Coll.) designated.

In the Sperry collection, for the time being, the group will be arranged as follows, *volantaria* Pears. being still held as a separate species pending receipt of more Colorado material.

viridipallens Hulst. . . . Colorado
volantaria Pears. . . . S.E. Arizona
martinaria Sperry. . . . Southern Arizona
masonaria Schaus. . . . Mexico
form *hyperella* Prout. . . Costa Rica

This leaves our common Southern California desert *Chlorochlamys* without a name and to be quite certain that this was undescribed, the author took the liberty of sending a good series to Mr. D. S. Fletcher at the British Museum and Mr. Fletcher kindly checked the genitalia in his usual careful and competent manner against *chloroleucaria* Gn., the type of its synonym *rectilinea* Zeller, the type of *densaria* Wlk. and one of its synonyms *deprivata* Wlk, a male and female type of *triangularis* Prout and the female type of *curvifera* Prout and still the California species remains unmatched and nearer *triangularis* Prout than anything else. On the strength of Mr. Fletcher's careful comparisons and my own checks against all other North American species in the Sperry collection, I make bold to describe this *Chlorochlamys* species from the Southwest giving it the name suggested by Mrs. Sperry before her death this past summer.

CHLOROCHLAMYS HESPERIA sp. n.

♂ & ♀ Palpi rosy brown above, ochreous beneath, in the ♂ short, scarcely exceeding the front, in the ♀ long, exceeding the front by more than the diameter of the eye. Front garnet-brown, vertex warm-buff as is also the antennal shaft. In the ♂ the antennal pectinations, especially proximal, flecked with dark brown. Legs rose-brown above, buff beneath. Thorax, abdomen above and both wings chromium-green in fresh specimens, fading

through yellowish-glaucous to pale olive-buff. The upper side of the distal half of the scale is laved with the darker green, the proximal half being almost without a green tint and the whole underside of the scale being a glistening gray-green, the vestiture is rough and this accounts for an occasional specimen with darker median area. The costa of the primaries is broadly warm-buff with a rose-brown tinting on the extreme edge. There is a narrow dorsal band of warm-buff extending the entire length of the abdomen and the underside and the lateral tufting of the ♂ and most of the last four ♀ abdominal segments, both above and beneath, are light to warm-buff, as is also the maculation of the wings. All are Ridgway colors.

Forewing: T.a. line from costa at $1/3$ out, perpendicular to costa to cell, curving in the cell until perpendicular to inner margin at $2/5$ out. The line is $1/4$ mm. wide and distinct, slightly larger at costa; t.p. line from costa at $2/3$ curving inward to vein 5 thence nearly straight to inner margin at $4/5$ out from base, t.p. line slightly wider than t.a. and the triangular inception at costa is over $1/2$ mm. wide. There is a narrow, light buff, terminal line at the base of fringe and the fringe is light green proximally and light buff distally. There is no discal dot.

Hindwing: T.a. line absent; t.p. line crosses the wing in a flat curve from costa to inner margin $2/3$ out from base. No discal dot; fringes as in primaries.

Beneath, both wings a shining, light grey-green. The basal area of primaries somewhat darker. The costal warm-buff band is rosier at the base than above, t.p. lines of primaries and secondaries showing dimly through as does the very narrow, terminal, light buff line. Fringes as above; no discal dots on either wing. Expanse ♂ 13-16 mm.; ♀ 15-18 mm.

Holotype ♂ Borrego, California, Feb. 27, 1950, Grace H. & John L. Sperry, coll. and in the collection of Grace H. & John L. Sperry.

Allotype ♀ Tub Canyon, Borrego, California, April 7, 1949, same collectors and in the Sperry collection.

Paratypes: It seems best to designate a rather large number of these and to distribute these widely. They comprise 119 ♂ 16 ♀ from Borrego or Tub Canyon, Borrego, California (the localities are 4 miles apart) taken by Grace H. & John L. Sperry or by Noël Crickmer mostly in March and April but with one October and several November records otherwise from Feb. 26 to June 30, 1945 to 1950. Also specimens from nearby parts of the Colorado and Mojave deserts of California taken by Grace H. & John L. Sperry as follows: 7 ♂ Split Rock Tank, May 19 to 31, 1938; 3 ♂, 1 ♀, 12 mi. south of Cave Spr. May 3, 1939; 1 ♂ Rock Spr., May 13, 1937; 3 ♂ Split Mt. Canyon, Apr. 12, 1939;

7 ♂ 5 ♀ Providence Mts., May 10, 11, 1936; 1 ♂ 1 ♀ Morongo Valley, May 13, 1937; 1 ♂ Ivanpah Mts., July 27, 1935; 1 ♂ 1 ♀ Mexican Wells, July 7, 1937; 1 ♀ Indio, Mar. 25, 1941; 1 ♀ Bullion Mts., Apr. 6, 1934, also 1 ♀ Hidden Valley, May 19, 1946; Melander and 2 ♀ Bouquet Canyon, Aug. 6, 1938, Westerland.

These will be distributed to the Los Angeles County Museum, California Academy of Science Museum, U. S. National Museum, British Museum, French National Museum, Canadian National Museum, American Museum of Natural History, Museum of Comparative Zoology, Nova Scotia Museum of Science, and collections Crickmer, Bower, Buchholz and Sperry.

The ♂ genitalia are similar to the genitalia of *chloroleucaria* Gn. but the cluster of spines at the tip of the needle-like aedeagus are cone shaped and robust, whereas those of *chloroleucaria* are flat and appressed at the apex of the organ. In the ♀ *chloroleucaria* has a rather large, heavily sclerotized plate, in *hesperia* the plate is much smaller.

Since 1938 there has been in the Sperry collection a small series of an unknown *Chlorochlamys* from South Florida, it was one of those things one is always going to work up and never does, but receipt of a series of this same insect from my friend Mr. C. P. Kimball of Rochester, N. Y. taken by him in Sarasota County, Florida provided the necessary incentive and Mr. D. S. Fletcher kindly compared these with specimens in the British Museum and states it is *Chloropteryx paularia* Moeschler and that, as there is no apparent production of the wings at vein 6 of the forewings and vein 4 of the hindwings and as the genitalia are congeneric with *Chlorochlamys* it follows that *paularia* is, as Prout suggested (Seitz, VIII, 63) probably better placed in the genus *Chlorochlamys*. The author believes that this is a new record for this species in the United States and that it should be added to our check list.

DREPANULATRIX ELLA Hulst

Receipt of a single ♂ specimen which is very probably this species from Mr. Edward C. Johnston of Seattle again stirs interest in this elusive insect. It was taken in Brooks Mem. Park, south of Yakima, Wash. on May 30. It is about the size of *bifilata* Hulst (30 mm.) and the ground color of the forewings is an orange buff rather heavily irrorate with brownish fuscous, the hind wings lighter. T.a. line from 1/4 out, narrow, distinct, perpendicular to costa to cell then curving smoothly to inner margin at 1/3; median line indicated, subparallel, at 1/3 on costa fading out in cell. T.p. line heaviest of the lines, from costa at 2/3 smoothly curving across the cell then nearly straight to inner margin at 2/3. No lines on secondaries. Distinct discal dots on all

wings outside the median line of primaries. Terminal black dots on veins, both wings.

In the ♂ genitalia the valvæ are narrower and less hairy than in *bifilata* and bear small hairy pads at the base of the costa, the uncus is also narrower and the two spines on the vesica have rounded spots at their tips. In the Sperry collection *ella* Hulst is now carried as a good species as are also incidentally *verdiaria* Grossb., *rindgearia* Sperry, and *ruthiaria* Sperry, as the author does not consider that sufficient evidence has as yet been presented to warrant the placing of these in synonymy or as forms of another species.

SNOWIA WALTONARIA Sperry

Among many interesting species received by the author in the Spring of 1950 through the kindness of Mr. Chester A. Thomas of Zion and Bryce National Parks there was a single ♀ of *Snowia montanaria* Neum. As the author's series of this species was made up entirely of males this specimen allowed the making of a slide of the female genitalia and the definite placing of *Azelina waltonaria* Sperry (Bull. So. Calif. Acad. Sci. XLVIII, 10, 1949) in the genus *Snowia* Neumoegen.



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NATURAL HYBRIDS BETWEEN DUDLEYA AND HASSEANTHUS

By REID MORAN

Each of the three plants described here appears to be a hybrid between a species of *Dudleya* and a species of *Hasseanthus*. The best proof of hybrid origin would be duplication by artificial hybridization. Even without this proof, however, evidence from morphology and distribution makes it appear almost certain that these plants are hybrids. Each of them is morphologically intermediate between the supposed parents. Each of them has been found only in the small areas where the supposed parents grow together. And each of them has been found only as rare individuals, whereas *Dudleya* and *Hasseanthus* usually are abundant where they occur at all. If these new plants were not hybrids, it seems highly improbable that this unusual combination of circumstances would recur at four localities.

The first putative hybrid was found by accident, and its parentage was deduced from morphology and distribution. At another locality where the supposed parents occur together, like plants were then sought and found. The other two putative hybrids likewise were found by searching where their respective parents occur together. Thus at three localities hybrids were predicted and seeming hybrids then discovered. The success of the predictions supports the hypothesis of hybridity on which the predictions were based.

Dr. Charles H. Uhl of Cornell University has studied all of the hybrids cytologically. He reports no sign of the meiotic irregularities that might be expected in hybrids of such seemingly diverse parents as those postulated. In any one hybrid, regular meiosis might seem to oppose the evidence for hybridity. But the total of this evidence for the three hybrids seems too strong to be thus controverted. Regular meiosis therefore seems to indicate not that the plants are non-hybrid but rather that the two parental species of each hybrid are genetically closer to each other than their present classification might suggest.

Little evidence is available concerning the fertility of the hybrids. Regular meiosis, of course, does not necessarily indicate high fertility. Mature pollen of six collections contained 7 to 56 per cent of bad grains; however, some collections of the parental species have almost as high a percentage of bad pollen. At least

one of the hybrids gives evidence of some fertility: one individual shows a recombination of parental characters suggesting that it is a second-generation hybrid.

The occurrence of hybrids between *Dudleya* and *Hasseanthus* suggests that the status of these genera might well be re-evaluated. This will be done elsewhere, with the presentation of other relevant data.

DUDLEYA ATTENUATA subsp. *ORCUTTII* X *HASSEANTHUS VARIEGATUS*, hybrida nova.

Planta inter parentes media. Caulis præcipuus plerumque (ut apud *Hasseanthum*) subterraneus brevis erectus simplex, interdum longior raroque bifurcatus. Rosulæ folia forma ut apud subsp. *Orcuttium* sed basin versus supra complanata, subsp. *Orcuttio* similia glauca, ante anthesi marcescentia vel aliquæ persistentia. Petala pallide lutea. Folliculi adscendentes-patentes, marginibus ventralibus circa 30-45° acclivibus.

Primary stem erect, rarely branching, 1-4 cm. long, 3-8 mm. thick, mostly cormlike but sometimes elongating considerably and rather rapidly as shown by persistence of old floral stems and leaf scars as much as 2 cm. below the apex and by occasional separation of leaf bases on the stem. Rosette leaves apparently about 8-15, withering before anthesis or a few large ones or several small ones remaining, glaucous, linear-oblongate, acute, scarcely narrowed toward the base, the mature ones 4-7 cm. long, 1½-2½ mm. wide, terete above, ventrally flattened below and with acute margins toward the base, the base 6-10 mm. wide, about ½-2 mm. high. Floral stems 6-18 cm. high, 1-1½ mm. thick at the base, 1½-3 mm. thick toward the middle, with 8-16 ascending leaves. Cauline leaves triangular-lanceolate, acute, the lowermost 1-2½ cm. long, 3-4 mm. wide. Inflorescence two-branched, the cincinni 1-4 cm. long, with 2-13 flowers. Pedicels erect, 0-2 (-6) mm. long. Calyx 2½-3½ mm. high, 3-4 mm. wide, rounded below, the segments triangular-ovate, acute, 2-3 mm. long, 1½-2 mm. wide. Petals pale yellow below, whitish above, red-flecked on the keel, elliptic-lanceolate, acute, 5-7 mm. long, about 2½ mm. wide, erect in the lower two-fifths, widespreading above, connate ¾-1½ mm. Filaments 4-5 mm. long, the antesealous adnate 1-1½ mm., the epipetalous adnate 1½-2 mm. Anthers about 1 mm. long, yellow to red. Scales about ½ mm. wide. Carpels suberect but separated, the ovaries 3-4 mm. long, with about 8-16 ovules, the styles about 1½ mm. long. Follicles ascending, the ventral margins about 30-45° above the horizontal. Chromosome number: $n=17$.

TYPE COLLECTION: Edge of ocean bluff 5.8 miles below Rancho Cuevas, Baja California, Mexico (near 32° 15¼' N, 116°



PLATE 19

Left, *Dudleya attenuata Orcuttii*; center, hybrid (3397); right, *Hasseanthus variegatus*. Near Rancho Cuevas, April, 1950.

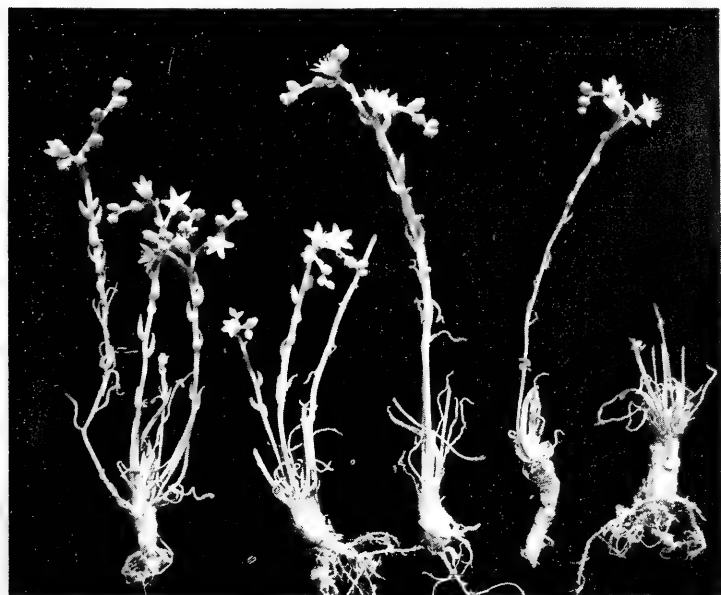


PLATE 20

Dudleya attenuata Orcuttii X *Hasseanthus variegatus* (3397).
Near Rancho Cuevas, April, 1950.

57¾' W), April 26, 1950, *Moran* 3397. The type specimen is number 806,719 in the Herbarium of the University of California at Berkeley.

DISTRIBUTION: Known only from the type locality.

At the type locality both *Dudleya attenuata* (S. Watson) Moran subsp. *Orcuttii* (Rose) Moran and *Hasseanthus variegatus* (S. Watson) Rose are plentiful along the edge of the ocean bluff. Though the hybrids were readily detectable because of the intermediate color of their flower buds, a careful search revealed only ten. A month later, when the flowers were open, four more hybrids were found.

The two parental species occur together also about one half mile south of Rosarito Beach and about one half mile south of Rancho Cuevas. No hybrids were found at these localities.

In most respects the hybrid is intermediate between the parental species. In the shape and glaucousness of the rosette leaves, however, it is more like the *Dudleya*. The primary stems are mostly cormlike, as in *Hasseanthus* and as in the other two *Dudleya*-*Hasseanthus* hybrids; but they may elongate and even branch. This variation suggests that perhaps not all plants are first-generation hybrids and hence that the hybrid is not completely sterile. This suggestion, however, is not so strong as in the hybrid of *D. edulis* and *H. Blochmaniae* subsp. *brevifolius*, discussed below.

Dr. Uhl reports that in the hybrid, as in the parental species, the haploid chromosome number is 17. He found no sign of meiotic irregularity.

DUDLEYA EDULIS X HASSEANTHUS BLOCHMANIÆ subsp. BREVI-FOLIUS, hybrida nova.

Planta inter parentes media. Ut apud *Hasseanthum* caulis præcipuus subterraneus brevis erectus simplex. Rosulæ folia plerumque oblanceolata interdum latiora, subacuta, usque ad anthesim vel aliquæ per æstatem persistentia. Flori inodori.

Corms oblong, 1-2½ cm. long, 5-12 mm. thick. Rosette leaves 6-15, all withering before anthesis or a few persisting through the summer, mostly linear-oblanceolate, acute or subacute, 1-6 cm. long, 5-10 mm. wide at the base, 1½-6 mm. wide just above the base, 2-8 mm. wide above, flattened ventrally and 1-2 mm. thick toward the base, flattened or subterete and 3-4½ mm. thick toward the apex; rarely the outer few leaves spatulate, 1½-3½ cm. long, 9-12 mm. wide. Floral stems 7-25 cm. tall, 2-3½ mm. thick at the base, 3-5 mm. thick toward the middle. Cauline leaves triangular-ovate to -lanceolate, obtusish or abruptly acute, turgid, the lowermost 8-30 mm. long, 5-10 mm. wide, 3-5 mm. thick.

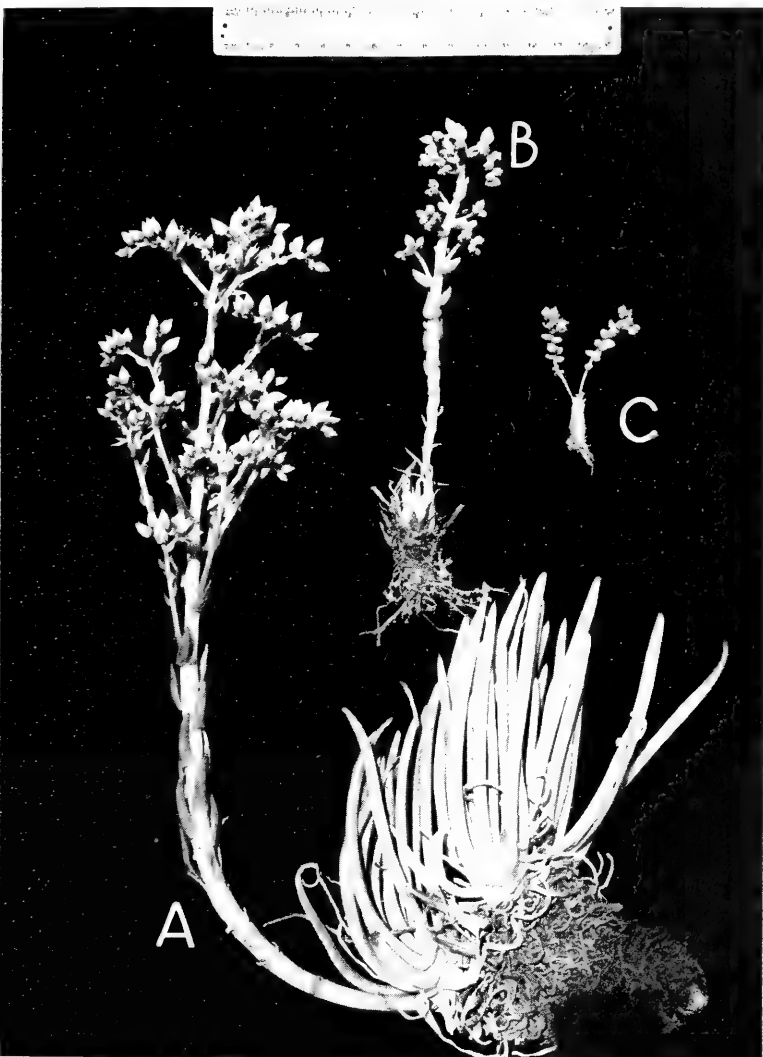


PLATE 21

A, *Dudleya edulis*; B, hybrid (3070); C, *Hasseanthus Blochmaniae brevifolius*, Torrey Pines, May, 1948.

	DUBLEYA ATTENUATA subsp. ORCUTII	HYBRID	HASSEANTHUS VARIEGATUS
Primary stem	(Caudex) multidichotomous Elongating to 15 cm. or more, 3-10 mm. thick	Usually cormlike and unbranched Sometimes elongating, 1-4 cm. long, 3-8 mm. thick	(Corm) unbranched Not elongating, 1-2½ cm. long, 5-10 mm. thick
Rosette leaves	Mostly 10-15, evergreen Glaucous Linear-oblancoolate, acute Terete 3-8 cm. long, 2-5 mm. wide	8-15, withering before anthesis or some persisting Glaucous Linear-oblancoolate, acute Terete above, ventrally flattened toward base 4-7 cm. long, 1½-2½ mm. wide	4-8, withering before anthesis Green Oblanceolate, subacute Ventrally flattened 1-4 cm. long, 4-7 mm. wide
Leaf base	5-10 mm. wide, 2-5 mm. high	6-10 mm wide, ½-2 mm high	3-5 mm. wide, very thin
Petals	White Connate about 1½ mm.	Pale yellow, whitish above Connate ¾-1½ mm.	Bright yellow Connate about ½ mm.
Anthers	Red	Yellow to red	Yellow
Ovules	About 14-18	About 8-16	About 8-12
Follicles	Ascending, the ventral edge about 45-60° above the horizontal	Ascending-spreading, the ventral edge about 30-45° above the hor- izontal	Widespreading, the ventral edge about 0-30° above the horizontal
Chromosomes	$n=17$	$n=17$; meiosis normal	$n=17$

TABLE 1

Inflorescence narrow to open, of 3 to several branches which may bear 1-2 lateral branches. Cincinni 2-10 cm. long, bearing 2-12 erect odorless mostly subsessile flowers. Sepals narrowly triangular-ovate, acute, $2\frac{1}{2}$ - $3\frac{1}{2}$ mm. long, $1\frac{1}{2}$ - $2\frac{1}{2}$ mm. wide. Petals white with red-flecked keel, elliptic, acute, 6-13 mm. long, $2\frac{1}{2}$ - $4\frac{1}{2}$ mm. wide, ascending below and connate $1-1\frac{1}{2}$ mm., widespreading or slightly reflexed in the upper three-fifths. Filaments erect, $5-7\frac{1}{2}$ mm. long, the epipetalous adnate $1\frac{1}{2}$ - $2\frac{1}{2}$ mm., the antesepalous adnate $\frac{3}{4}$ - $1\frac{1}{2}$ mm. Anthers red to yellow, $1-1\frac{1}{2}$ mm. long. Scales whitish or yellowish $\frac{1}{2}$ -1 mm. wide. Carpels ascending-spreading, the ovaries 3-6 mm. long, the styles 2-3 mm. long. Seeds light brown, about $1\frac{1}{4}$ mm. long. Chromosome number: $n=17$.

TYPE COLLECTION: Eastern edge of mesa, Torrey Pines Park, San Diego County, California, May 14, 1948, *Moran 3070*. The type specimen is number 806,720 in the Herbarium of the University of California at Berkeley.

DISTRIBUTION: Otherwise known only from Del Mar, San Diego County.

At Torrey Pines *Hasseanthus Blochmaniae* (Eastwood) Rose subsp. *brevifolius* Moran grows on bare flat areas near the edge of the mesa. *Dudleya edulis* (Nuttall) Moran grows on banks about the mesa and with other vegetation at the edge of the mesa. It is only near the edge of the mesa, where the parental species grow together, that the hybrid has been found. Individuals of the parental species are relatively abundant. But despite several hours of searching during each spring season of the last four years, only about a dozen hybrids have been found in all. At Del Mar the situation is similar, though the two parental species occur together over perhaps a wider area. Three hybrid plants were found there in the spring of 1950.

In some characters the hybrids do not fall exactly between the parental species. Thus leaf width is sometimes greater in the hybrid than in either parent. Presumably the *Hasseanthus* contributes to the hybrid a factor for relative breadth, whereas the *Dudleya* contributes a factor for larger size. Table 2 shows the range for each character in all plants examined and not just for those that are most nearly intermediate.

Specimens of the hybrid, though in most respects intermediate between the parental species, varied considerably among themselves. One plant (3207A) seemed to show a recombination of parental characters such as might be expected in a second-generation hybrid: it had some broad spatulate leaves, recalling those of the *Hasseanthus*, though larger; but the inflorescence was very

broad and open and the petals somewhat reflexed, recalling the *Dudleya* (plate 22). This plant suggests that the hybrid is at least partially fertile.

Dr. Uhl has studied four collections of the hybrid from Torrey Pines (2147, 3070, 3207, 3207A) and one from Del Mar (3317). Just as in each of the parental species, the haploid chromosome number is 17. He reports that meiosis, microspore quartets, and young pollen grains all appear perfectly normal.

Young seedlings of *Dudleya edulis* may sometimes be mistaken for the hybrid. But since these do not flower, any evidence of a floral stem identifies the hybrid. In the absence of floral stems, a doubtful individual can be identified by growing it for a

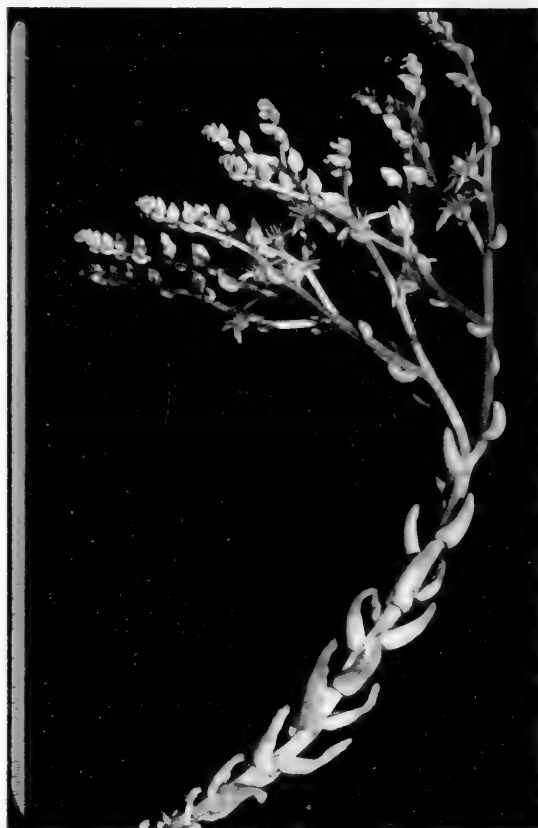


PLATE 22

Inflorescence of *Dudleya edulis* X *Hasseanthus Blochmaniae brevifolius* (3207A). Cultivated plant from Torrey Pines, May, 1950.

few months: *Dudleya* seedlings quickly outstrip the hybrid and take on their distinctive adult appearance.

DUDLEYA EDULIS X *HASSEANTHUS BLOCHMANIÆ* subsp. *BLOCHMANIÆ*, hybrida nova.

Planta inter parentes media. Hybridæ antecedenti persimilis, sed cormus globosior et folia rosulata caulinaque fortasse angustiora.

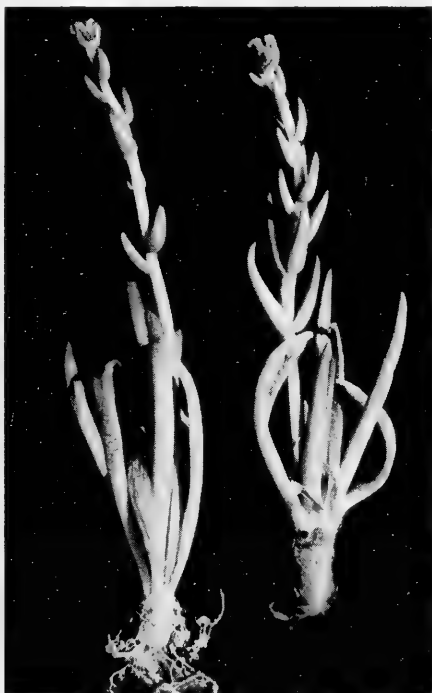


PLATE 23

Dudleya edulis X *Hasseanthus Blochmaniae* (3393).
Pacific Beach, April, 1950.

Corms globose to oblong, 6-15 mm. long, 6-13 mm. thick. Rosette leaves linear to linear-lanceolate or -oblanceolate, acute or subacute, 3-7 cm. long, 5-10 mm. wide at the base, 2-6 mm. wide and $1\frac{1}{2}$ -2 mm. thick just above the base, 3-8 mm. wide and 2-4 mm. thick above. Floral stems 6-11 cm. tall, about 2 mm. thick at the base and $2\frac{1}{2}$ mm. thick toward the middle, with 10-14 ascending leaves. Cauline leaves triangular-lanceolate, acute, the

lowermost 9-18 mm. long, 4-6 mm. wide. Inflorescence of 1-3 branches that are simple or once branched, the ultimate branches 1-7 flowered. Flowers mostly subsessile, 11-18 mm. in diameter, odorless (?). Sepals triangular-ovate, acute, 2-3 mm. long, $1\frac{1}{2}$ -2 mm. wide. Petals white with purple-marked midrib, 8-10 mm. long, $2\frac{1}{2}$ - $3\frac{1}{2}$ mm. wide, erect below and connate about $1\frac{1}{2}$ mm., spreading in the upper three-fifths or slightly reflexed. Anthers yellow to red, about $1\frac{1}{2}$ mm. long. Scales yellowish, about $\frac{3}{4}$ mm. wide. Carpels sometimes red-marked ventrally even before all anthers have dehisced (as in *D. edulis* at this locality), the ovaries 3- $4\frac{1}{2}$ mm. long, with about 18 ovules, the styles 2- $2\frac{1}{2}$ mm. long.

TYPE COLLECTION: Ocean bluffs just north of Loring Street, Pacific Beach, San Diego County, California, May 29, 1949, Moran 3262. The type specimen is number 792,929 in the Herbarium of the University of California at Berkeley.

DISTRIBUTION: Known only from the type locality.

At the type locality both *Dudleya edulis* (Nuttall) Moran and *Hasscanthus Blochmaniae* (Eastwood) Rose subsp. *Blochmaniae* are abundant. But in three visits to the area, a total of only seven bloomin' hybrid plants was found. Also seen were a few sterile plants which may be hybrids or may be seedlings of *D. edulis*.

At San Clemente, Orange County, *Dudleya edulis* and *Hasscanthus Blochmaniae* subsp. *Blochmaniae* occur together over a broad area. A careful search revealed no undoubted hybrids but only a few seedlings that probably are of *D. edulis*.

Dr. Uhl has studied two collections of the hybrid (3315, 3393) and reports that, as in the parental species, the gametic chromosome number is 17. He found no sign of irregularity.

This hybrid of *D. edulis* with *H. Blochmaniae* subsp. *Blochmaniae* is very similar to the preceding hybrid, of *D. edulis* with *H. Blochmaniae* subsp. *brevifolius*. The seven individuals of the *Blochmaniae* hybrid were relatively uniform in appearance, whereas the 15 or so individuals of the *brevifolius* hybrid showed considerably more variation. Perhaps the *Blochmaniae* hybrids were all first-generation and the *brevifolius* hybrids included some that were second-generation.

On the basis of the few specimens available, it is difficult to distinguish between these two hybrids. However, there appear to be at least two differences between the hybrids paralleling differences between the parental subspecies of *H. Blochmaniae*. In the *brevifolius* hybrid the corms are somewhat more elongate; and the rosette and cauline leaves, at least in some specimens, are broader.

	HASSEANTHUS BLOCHMANIÆ subsp. BREVI-FOLIUS	HYBRID	DUDLEYA EDULIS
Primary stem	(Corm) hypogæus, unbranched 1½-3½ cm. long, 4-6 mm. thick	(Corm) hypogæus, unbranched 1-2½ cm. long, 5-12 mm. thick	(Caudex) epigeus branched to 10 cm. long, 1-3 cm. thick
Rosette leaves	Mostly 5-10, all withering a month or more before anthesis	6-15, lasting nearly till anthesis or a few persisting through summer and fall	15-25, evergreen
	Spatulate, rounded at apex	Mostly oblanceolate, acute or sub- acute	Linear, acute to subacuminate
	7-15 mm. long, 2-7 mm. wide above	1-6 cm. long, 2-8 (-12) mm. wide	8-20 cm. long, 4-9 mm. wide
	Abruptly contracted to a petiole ½-1 mm. wide	Gradually narrowed to about 1½- 6 mm. just above base	Not narrowed below
	1-2 mm. wide at base	5-10 mm. wide at base	12-20 mm. wide at base
Floral stems	4-11 cm. tall	7-25 cm. tall	25-40 cm. tall
	½-1 mm. thick at base	2-3½ mm. thick at base	4-10 mm. thick at base
	To 2½ mm. thick at middle	3-5 mm. thick at middle	Usually not thickened upward
Internodes	About 1½-2½ mm.	About 2-9 mm.	About 5-13 mm.
Cauline leaves	Orbicular-ovate, blunt	Triangular-ovate to -lanceolate, acute to subobtusè	Triangular-lanceolate, acute
	5-10 mm. long, 4-9 mm. wide	8-30 mm. long, 5-10 mm. wide	2-5 cm. long, 8-14 mm. wide
Inflorescence	Usually of 2-3 branches, which usually are simple	Of 3 to several branches, which usually are once branched	Usually of several branches, which usually are once or twice branched
Flowers	With odor	Without odor	Without odor
Sepals	Ovate	Narrow ovate	Oblong ovate
Petals	White with pink midrib 6-8½ mm. long, 2-3½ mm. wide	White with pink midrib 6-13 mm. long, 2½-4½ mm. wide	White 8-10 mm. long, 2-3 mm. wide
	Connate about ¾ mm.	Connate 1-1½ mm.	Connate 1½-2 mm.
Chromosomes	n=17	n=17; meiosis normal	n=17

TABLE 2

DESCRIPTIONS OF TWO NEW SPECIES OF MARINE
PELECYPODS FROM WEST MEXICO

By LEO GEORGE HERTLEIN

During the course of study of pelecypoda occurring in tropical west American waters two species, apparently undescribed, have come to my attention. These species, one referable to the genus *Ostrea*, the other to *Tagelus*, are here described as new.

OSTREA CORTEZIENSIS Hertlein, new species

Plate 24, Figures 1 and 2; Plate 25; Plate 26, Figure 7

Shell elongately ovate to subtrigonal in outline, moderately thick, beaks turned posteriorly; lower (left) valve moderately convex, upper valve flattish or gently convex; early portion of upper valve with 8-10 weak, scaly, radiating costæ ending about 75 mm. from the beak, the remainder of the shell concentrically lamellose with faint traces of superficial radial sculpture, colored grayish-white to brownish-white, the brownish color more pronounced on juvenile shells; interior of lower valve with a large rather broad, ligamental area which is lightly transversely grooved, about 4 of these coarser than the others, the ligamental area is bordered on each side by a narrow groove; the anterior portion of the ligamental area centrally overhangs the body cavity; adductor muscle impression posteriorly situated, broadly semi-crescentic above, white with traces of purplish-brown concentric bands or lines; the remainder of the interior white with occasional traces of purplish-brown. Upper (right) valve usually flat or nearly so, exteriorly it is similar to the lower valve in coloration but it lacks the indistinct radiating furrows; interiorly the anterior portion of the ligamental area is raised centrally; adductor impression a little larger than that of the lower valve and truncated above by white shell material. Holotype: height, 153 mm.; width (maximum), 98 mm.; convexity (both valves together), approximately 56 mm.

Holotype, No. 4288 (Calif. Acad. Sci. Dept. Paleo. Type Coll.), from Loc. 28186 (C.A.S.), Kino Bay, Sonora, Mexico, Gulf of California; H. N. Lowe Coll. Paratype, No. 4289, from Guaymas, Mexico.

This species has generally been referred by various authors to *Ostrea chilensis* Philippi.¹ That species was originally described

¹*Ostrea chilensis* Philippi, in Küster, Conchyl.—Cab. von Martini und Chemnitz, Bd. 7, Abt. 1, Taf. 13, figs. 7, 8, 1844, p. 74, 1868. "Aufenthalt an den Küsten von Chili."—Dall, Proc. U. S. Nat. Mus., Vol. 37, 1909, pp. 148, 255, pl. 26, fig. 1. [Not the records north of Peru].—Lamy, Journ. de Conchyl., Vol. 73, No. 1, 1929, p. 41.

from Chile. It occurs along the coast of that country but it is uncertain as to the northern limit of its range. It also has been recorded from beds of Pleistocene age in Chili by Steinmann² who mentioned that the species was not known living along northern Chile.

Ostrea chilensis although in general features similar to the species in the Gulf of California, differs in a very important feature mentioned by Philippi in the original description in which he stated "Der Rand neben dem Wirbel jederseits ist bei jüngeren Schalen mit feinen Zähnen besetzt, bei älteren fehlen diese Zähne ganz oder es ist nur der eine Rand damit versehen." Philippi's illustrations here reproduced (plate 25, figures 3, 4), reveal an oyster of subrounded outline with straight beaks, but the denticles near the beak mentioned in the description are not certainly discernible. However, 9 to 10 denticles or traces of such, are present on specimens of *O. chilensis* from Calbuco, Chile, received from A. Carcelles, in the collections at Stanford University (plate 25, figure 2). No trace of such denticles has been observed on any of the specimens studied from the Gulf of California. The base of the hinge of the upper valve of the Chilean shells does not possess such a large transverse ridge and the interior is more greenish-

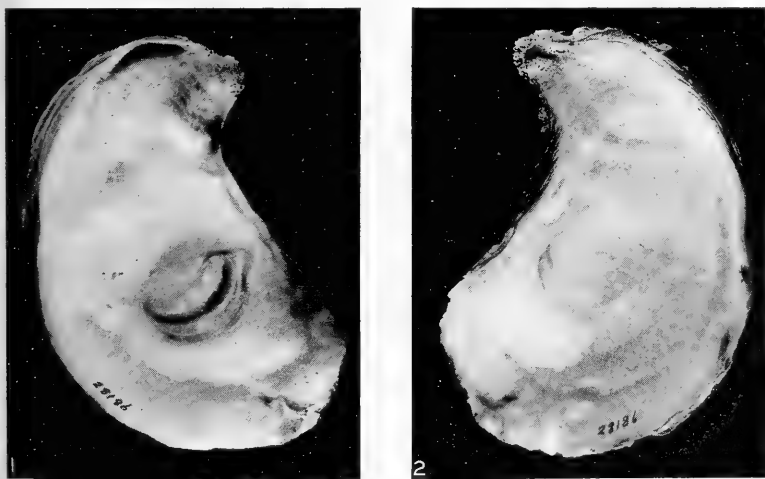


PLATE 24

Fig. 1. *Ostrea corteziensis* Hertlein, n. sp. Holotype, upper (right) valve, from Punta Penasco, Sonora, Mexico, in the Gulf of California. Height, 153 mm.; maximum width, 98 mm. View of the interior.

Fig. 2. *Ostrea corteziensis* Hertlein, n. sp. Holotype, lower (left) valve. View of the interior.

²Steinmann, G., Neues Jahrb. f. Miner. Geol. u. Palæo., Beil. Bd. 10, 1895-1896, p. 541. "jungpleistocänen Loza," from Coquimbo to Andacollo, Chile.

white in comparison to that of the shells from the Gulf of California. It appears therefore that this northern form is specifically distinct from the Chilean species.

Ostrea cibialis Hupé³ and *O. longiuscula* Hupé⁴ were regarded by Dall as identical with *O. chilensis*. It appears also that *O. chilensis* Sowerby⁵ is at most only varietally distinct if at all. Judging from the illustrations of those forms the one which bears the greatest resemblance to the species occurring in the Gulf of California is the one described as *O. longiuscula*. That name was based upon an elongate oyster approximately 8 inches long and 3 inches wide, with the interior wholly white, the exterior with reddish rays on a white ground. The muscle impression was described as small and subcentral, irregular, trigonal with obtuse angles. No mention was made of denticles on the margin. However, it may be that these were lacking or if minute they may not have been noticed. The type locality was Coquimbo, Chile. The original illustration showing the interior of the lower valve is here reproduced on plate 25, figure 1. The species was said to be very similar to *Ostrea virginica* but smaller. If this be regarded as a valid species there is no evidence, so far as known, that it extends northward into tropical water. The species occurring in the Gulf of California has not been recorded as occurring even in the slightly cooler waters of the west side of the peninsula of Lower California.

Peile⁶ cited *Ostrea longiuscula* as occurring on the "Mancora Tablazo" of Peru and stated that at the present time this species

³*Ostrea cibialis* Hupé, Hist. Fis. y Pol. de Chile, Zool., Vol. 8, 1854, p. 281, Atlas, Vol. 2, Malacol., pl. 5, fig. 1. "Habita las costas de Chiloe."

⁴*Ostrea longiuscula* Hupé, Hist. Fis. y Pol. de Chile, Zool., Vol. 8, 1854, p. 282, Atlas, Vol. 2, Malacol., pl. 5, figs. 3, 3a. "Se halla tambien en Coquimbo."

⁵*Ostrea chilensis* Sowerby, Conch. Icon., Vol. 18, *Ostræa*, February, 1871, sp. 33, pl. 15, fig. 33. "Hab. Chiloe."

⁶Peile, A. J., in Bosworth, T. O., Geol. Tert. and Quat. in Northwest Peru (Macmillan & Co., Ltd., London), 1922, p. 177.

EXPLANATION OF FIGURES ON PLATE 25

Fig. 1. *Ostrea chilensis* Philippi. Reproduction of original figure of *Ostrea longiuscula* Hupé in Gay's Hist. Fis. y Pol. de Chile, Atlas, Vol. 2, Malacol., plate 5, figure 3a, 1854. Coquimbo, Chile. View of interior of lower valve.

Fig. 2. *Ostrea chilensis* Philippi. Hypotype, upper valve (Stanford Univ. Coll.), from Calbuco, Chile. Height, 61 mm.; maximum width, 48.6 mm. View showing interior. Small denticles are present along the margin just below the hinge.

Fig. 3. *Ostrea chilensis* Philippi. Reproduction of original figure in Conchylien-Cabinet von Martini und Chemnitz, Bd. 7, Abt. 1, Tafel 13, Figure 8. View showing position of muscle impression.

Fig. 4. *Ostrea chilensis* Philippi. Reproduction of original figure in Conchylien-Cabinet von Martini und Chemnitz, Bd. 7, Abt. 1, Taf. 13, figure 7. View showing the upper valve and a portion of the lower one.

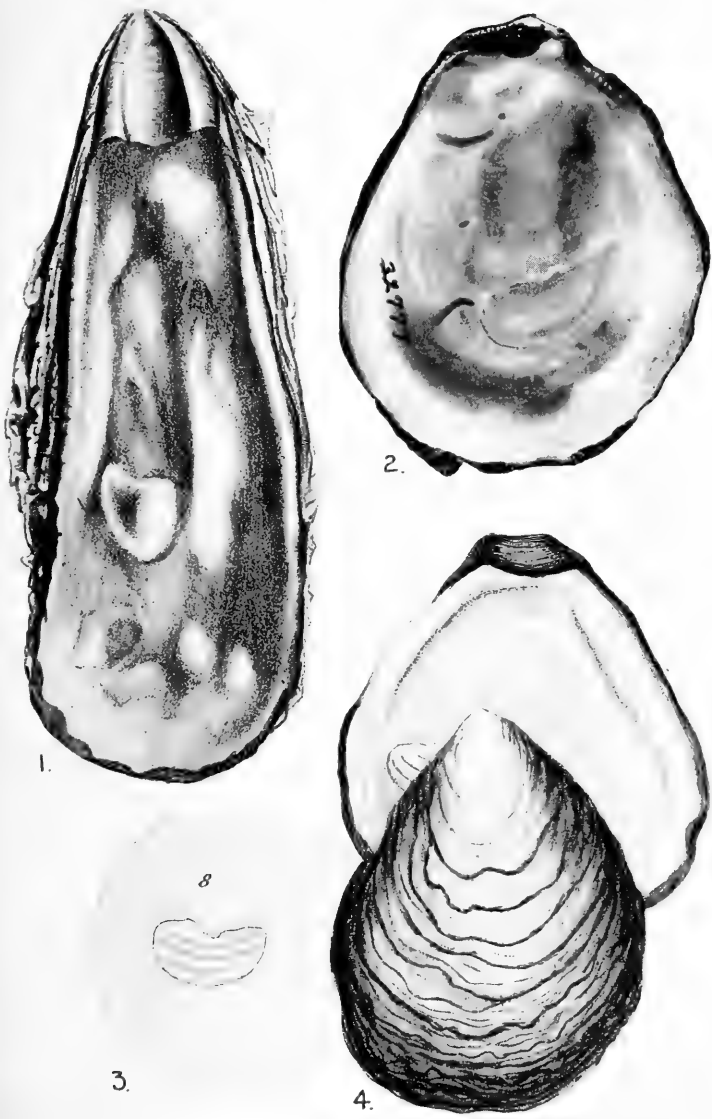


PLATE 25

occurs farther south. He considered the Mancora Tablazo to be of Quaternary age but Pilsbry & Olsson⁷ recently referred those deposits to the Pliocene. Smith⁸ cited *Ostrea chilensis* as occurring in the Quaternary at Manta, Ecuador, and Barker⁹ later cited "*Ostrea cf. chilensis*" as occurring in the Quaternary of the same region. Specimens from the Quaternary of Ecuador labelled *O. chilensis* in the collection at Stanford University, made available to the writer by Dr. A. M. Keen, are referable to *O. iridescens* Gray. Lamy, 1929, mentioned that specimens of an elongate, edible oyster from Guayaquil, Ecuador, in the collections of the Museum of Natural History in Paris were labelled *Ostrea coracoides* by Valenciennes. It appears however that this name was never validated by formal publication. Hoffstetter¹⁰ did not cite either *O. chilensis* or *O. longiuscula* among the species which he recorded from terrace deposits of Ecuador in his recent papers.

The new species, *O. corteziensis*, apparently has been present in the Gulf of California region at least since the Pliocene.¹¹ Specimens apparently identical with Recent shells have been collected from beds of Pliocene age in Lower California and from islands in the Gulf of California. It is quite similar to *Ostrea californica* Marcou¹² which was originally described from beds of Pliocene age in Imperial County, California. It differs from Marcou's species chiefly in the considerably greater width of the valves. Another similar species is *O. engleknyi* Hertlein¹³ originally described from beds of lower or middle Miocene age on Santa Rosa Island, California.

The species here described as new is very similar to the east American *Ostrea virginica* Gmelin,¹⁴ a fact recognized long ago by Carpenter¹⁵ and Mörch.¹⁶ It may be easily separated from

⁷Pilsbry, H. A., and Olsson, A. A., Proc. Acad. Nat. Sci. Philadelphia, Vol. 93, September 9, 1941, p. 1.

⁸Smith, J. P., Proc. Calif. Acad. Sci., Ser. 4, Vol. 9, No. 4, 1919, p. 135.

⁹Barker, G. W., Geol. Mag., Vol. 70, No. 824, 1933, p. 89. On the coast between Punta Mambra and Rio Real, Ecuador, Quaternary.

¹⁰Hoffstetter, R., Bol. Inform. Cient. Nac. (Quito), Vol. 2, Nos. 11 and 12, 1948, pp. 19-44 and Nos. 13-14, 1948, p. 74.

¹¹In some instances it has been recorded as a fossil under the name of *Ostrea chilensis* (Jour. Paleo., Vol. 5, No. 4, 1931, p. 366; Geol. Soc. Amer. Mem. 43, Pt. 2, 1950, p. 58, pl. 4, fig. 1).

¹²*Ostrea virginica* var. *californica* Marcou, Geol. North America (Zurich), 1858, p. 32, pl. 5, figs. 2, 2a. "In the Colorado desert, California; near Carrizo Creek, between San Diego and Fort Yuma." Miocene or Pliocene. Hanna, Proc. Calif. Acad. Sci., Ser. 4, Vol. 14, No. 18, 1926, p. 468, pl. 26, figs. 4-7 (as *Ostrea iridescens* Gray).—Hanna & Hertlein, Nautilus, Vol. 41, No. 2, 1927, pp. 45, 46 (as *Ostrea californica*).

¹³*Ostrea engleknyi* Hertlein, Jour. Paleo., Vol. 2, No. 2, June, 1928, p. 143, pl. 25, fig. 1. "About .4 kilometer southeast of spring (near Loc. 1154 C.A.S.), east of dike, near top of hill, Santa Rosa Island, California." Temblor, Lower Miocene."

¹⁴*Ostrea virginica* Gmelin, Linn. Syst. Nat., Ed. 13, Pars 6, 1790, p. 3336. Ref. cited: "List. Conch. t. 200, f. 34," "Chemn. Conch. 8, t. 73, f. 677,"; "B) List. Conch. t. 201, 35," "Chemn. Conch. 8, t. 74, f. 678," "Habitat in Oceano Americano E indico,"—Sowerby, Conch. Icon., Vol. 18, *Ostrea*, 1871, sp., 9, pl. 6, figs. 9a, 9b, 9c (as *Ostrea rostrata*). New York; Virginia; Canada.—Ryder, Fourth Ann. Rept. U. S. Geol. Surv. for 1882-1883 (issued 1884), pp. 317-333, pl. 77, figs. 1, 2; pl. 78, figs. 1, 2; pl. 79, figs. 1, 2, 3, 4; pl. 81, figs. 1, 2. Eastern North America, Recent.

¹⁵Carpenter, P. P., Cat. Mazatlan Shells, p. 159, March, 1856.

¹⁶Mörch O. A. L., Malakozool. Blätter, Bd. 7, p. 211, 1861.

Gmelin's species by the color of the adductor impression which is either wholly white or white with brownish-purple lines or flecks whereas that of *O. virginica* is wholly deep purple. Carpenter pointed out that although the shells of both species are variable in shape that of the east American species is generally straighter, shorter, thicker and with the adductor impression situated closer to the ventral margin.

Ostrea corteziensis occurs from Punta Penasco near the head of the Gulf of California (Sea of Cortez) south to Nicaragua and has been recorded from Panama. Whether or not it occurs farther south is not known with certainty although it may extend to Ecuador and northern Peru. It is said that oysters (presumably this species) from Mazatlan, Mexico, were transplanted into Newport Bay and Mugu Lagoon, California, about 20 years ago but this experiment was not a success. Galtsoff¹⁷ recorded a species under the name of *Ostrea chilensis* which he stated occurs abundantly in the waters of Panama. Judging from the illustrations the Panama shell is similar to *O. corteziensis*. The outer margins of the shells illustrated appear rather dark but according to Galtsoff the muscle impression is not pigmented. The species was said to thrive on a mud bottom especially near the mouths of rivers.

The specific name *corteziensis* is derived from that of the Sea of Cortez, a name often applied to the Gulf of California.

TAGELUS (MESOPLEURA) BOURGEOISÆ Hertlein, new species

Plate 26, Figures 5 and 6

Shell narrowly elongate, gently convex, beaks situated slightly posterior to the middle, anterior end broadly rounded, posterior end more narrowly, elliptically rounded; hinge with 2 fine, fragile teeth in each valve; an interior riblet slopes anteriorly from beneath the beak; pallial sinus extending to or almost to the internal riblet, unsymmetrically elliptical, the end pointing forward and gently downward, along the base confluent with the pallial line; exterior dark grayish-purple or brownish-purple, the internal rib showing through as a dark line, also there are 2 lighter colored, narrow, radial bands which slope posteriorly from the beaks; the whole covered with a shiny brownish periostracum; interior deep purple with areas of lighter grayish-purple. Dimensions of holotype: length, 34 mm.; distance from beak to anterior end, approximately 19.8 mm.; height, 11 mm.; convexity (both valves together), 5.9 mm.

Holotype, No. 9508 and paratype No. 9509 (Calif. Acad. Sci.

¹⁷Galtsoff, P. S., The Pearl-Oyster Resources of Panama. U. S. Dept. of Interior Fish and Wildlife Service. Spec. Sci. Rept.: Fisheries No. 28, May, 1950, p. 45, fig. 28.

Dept. Paleo, Type Coll.), from Salina Cruz, Mexico; Marie E. Bourgeois coll.

The shell of this new species is in its general features similar to those of *Tagelus politus* Carpenter.¹⁸ It can be easily separated from that species by the fact that the internal riblet slopes anteriorly from beneath the beak rather than posteriorly. There appears to be some variation in this character in both *T. politus* and the new species. In some small specimens the internal riblet extends nearly vertically from the beak. However, in such specimens, other characters may be relied upon to separate the two species. The new species also differs from *Tagelus politus* in other details as follows: the beak is more posteriorly situated, the posterior end is shorter and somewhat more tapering, the hinge teeth are very much finer, the pallial sinus is not symmetrically elliptical at the end which points forward and downward rather than straight forward, and the shell is usually thinner than that of the species described by Carpenter.

This species occurs as far south as the Santa Elena peninsula, Ecuador, where it was collected by Dr. Robert Hoffstetter. It is named for Miss Marie E. Bourgeois of Mixcoac, Mexico, who collected the type specimen.

¹⁸*Solecurtus politus* Carpenter, Cat. Mazatlan Shells, p. 27, August, 1855. "Hab.—Mazatlan: 4 specimens found with *affinis*: L'pool Col."

EXPLANATION OF FIGURES ON PLATE 26

Fig. 1. *Aspella bakeri* Hertlein & Strong, n. sp. Holotype, from Agua Verde Bay, Lower California, Mexico, in the Gulf of California. Length, 17.7 mm.; maximum diameter, 7.7 mm.

Fig. 2. *Aspella bakeri* Hertlein & Strong, n. sp. Holotype. Apertural view of specimen shown in Figure 1.

Fig. 3. *Marginella woodbridgei* Hertlein & Strong, n. sp. Holotype, from San José, Guatemala. Length, 12.3 mm.; maximum diameter, 7.2 mm.

Fig. 4. *Marginella woodbridgei* Hertlein & Strong, n. sp. Holotype. View of back of specimen shown in Figure 3.

Fig. 5. *Tagelus bourgeoisi* Hertlein, n. sp. Holotype, from Salina Cruz, Mexico; Marie E. Bourgeois coll. Length, 34 mm.; height, 11 mm. View showing exterior of both valves.

Fig. 6. *Tagelus bourgeoisi* Hertlein, n. sp. Holotype. View showing interior of the specimen shown in Figure 5.

Fig. 7. *Ostrea corteziensis* Hertlein, n. sp. Paratype, from Loc. 24075 (C. A. S.), Guaymas, Sonora, Mexico, in the Gulf of California, between tides. Height (upper valve), 137.6 mm.; maximum diameter, 62.5 mm. View showing exterior of upper valve and portions of the lower valve.

Fig. 8. *Latirus socorroensis* Hertlein & Strong, n. sp. Holotype, from Socorro Island, Revillagigedo Islands, Mexico. Length, 39 mm.; maximum diameter, 17 mm.

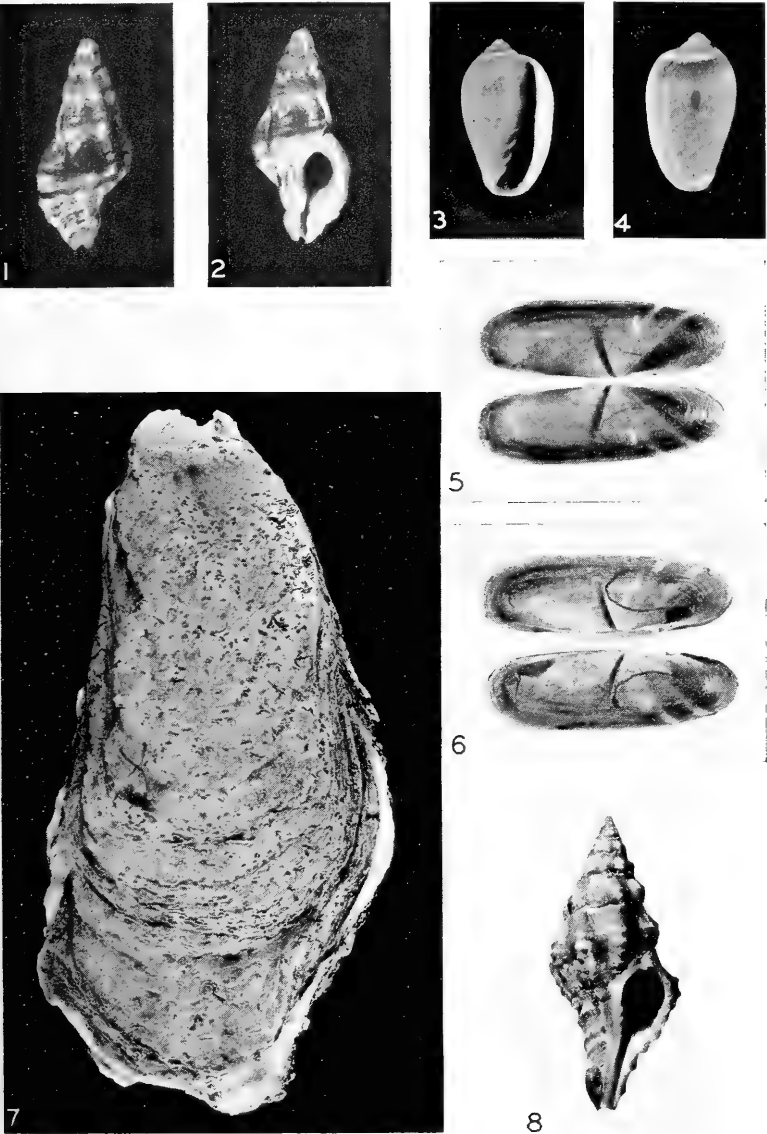


PLATE 26

DESCRIPTIONS OF THREE NEW SPECIES OF MARINE
GASTROPODS FROM WEST MEXICO
AND GUATEMALA

By LEO GEORGE HERTLEIN and A. M. STRONG

Three species of marine gastropods from tropical west American localities, apparently not described, have been noticed in the collections of the California Academy of Sciences. It appears desirable to place these interesting forms on record, and accordingly they are here described as new and accompanied by illustrations.

LATIRUS SOCORRENSIS Hertlein & Strong, new species

Plate 26, Figure 8

Shell turreted, yellowish-white covered with an orange-brown periostracum; nucleus very small, eroded, forming a sharp point to the spire; normal whorls 8, regularly increasing in size, shoulder subangulate above which they are slightly concave and below which they are broadly rounded; axial sculpture consists of 9 rounded ribs, strong over the lower half of the whorls, faint over the slightly concave upper half, fading out on the base, in addition to the ribs there are strong lines of growth over the entire surface; spiral sculpture on the spire consists of 2 equal raised cords on the lower half of the whorls which are strong on top of the axial ribs but faint in the interspaces, on the last whorl these are followed by 4 equally strong and equally spaced similar cords with 3 more widely spaced cords on the canal, occasionally a fine spiral thread occurs between the major spiral cords on the canal; aperture narrow, showing broken lines of small ridges deep within, canal narrow, open, about equal in length to the aperture, the edge of the outer lip finely serrated by the ends of the spiral cords; a siphonal fasciole is present, columella with 3 sharp plaits at the lower end. Dimensions of the type: length, 39 mm.; maximum diameter, 17 mm.

Holotype, No. 5896, paratypes Nos. 5897, 5897a, 5897b (Calif. Acad. Sci. Dept. Paleo. Type Coll.), from Loc. 23776 (C.A.S.), Socorro Island, Revillagigedo Islands, Mexico; G. D. Hanna and E. K. Jordan collectors, 1925. Also paratype No. 5898, from Loc. 23777 (C.A.S.), Clarion Island.

This new species bears a slight resemblance to *Latirus ceratus* Wood¹ but it differs from that species in the more slender form,

¹*Murex ceratus* Wood, Index Test., Suppl., 1828, p. 15. As *Turbinella cerata* on p. 57, pl. 5, fig. 15. (No locality cited).—Kiener, Spéc. Gén. et Icon. Coq. Viv., Canalifères, Pt. 2, *Turbinella*, p. 25, 1841, pl. 16, fig. 1, 1840. "Habite la mer Pacifique, les côtes de Masatlan."—Reeve, Conch. Icon., Vol. 4, *Turbinella*, 1847, sp. 37, pl. 7, fig. 37. "Hab. Gallapagos Islands (under stones at low water); Cuming."—Tryon, Man. Conch., Vol. 3, 1881, p. 88, pl. 67, fig. 120 (as *Latirus ceratus*).

longer canal, less strongly tuberculate shoulder and in lacking the well developed fine, concentric, secondary spiral threads. It also differs from *Latirus concentricus* Reeve² in that the whorls are angulated at the shoulder and in that no spiral sculpture is present on the whorls posterior to the angulation. The species here described as new was recorded by Strong & Hanna³ as occurring at Clarion and Socorro Islands under the name of *Latirus concentricus*.

GENUS ASPELLA Mörch

Aspella Mörch, Malakozool. Blätter, Bd. 24, 1877, p. 24, Sole species *Ranella anceps* Lamarck.—Dall, Bull. Mus. Comp. Zool., Vol. 18, 1889, p. 206.—F. C. Baker, Bull. Chicago Acad. Sci., Vol. 2, No. 2, 1895 p. 178. "Type. Trophon anceps, Lam."—Wenz, Handbuch der Paläozool. (Lfrg. 7), Bd. 6, Gastropoda, Teil 5, 1941, p. 1109. "Monotypus: *A. anceps* (Lamarck) [*Ranella*]."

Type (by monotypy): *Ranella anceps* Lamarck, Hist. Nat. Anim. s. Vert., Vol. 7, August, 1822, p. 154. "Habite . . ."—Chenu, Man. de Conchyl. Vol. 1, 1859, p. 156, fig. 722.

Shell with high spire, somewhat flattened, whorls rounded; nearly continuous varices present on each side and between these 4-6 varices (often worn and extending somewhat beyond the posterior end of whorl); spiral sculpture consisting of threads or rows of fine nodes; aperture small, ovate, with a short, recurved, open anterior canal, outer lip with a varix, the interior margin lightly denticulate, columella bent, smooth, inner lip slightly projecting; operculum with an apical nucleus.

The genus *Aspella* occurs worldwide in tropical and subtropical marine waters. It has been recorded as occurring from Miocene to Recent in Europe and in the Caribbean region.

Hörnes⁴ cited a species under the name of *Ranella anceps* Lamarck from the Miocene of Austria and Boettger⁵ described "*Ranella (Argobuccinum) emmæ*" from the Miocene of Hungary, a form which he compared to Lamarck's species.

Cossmann & Peyrot⁶ referred a species from the Burdigalian

²*Turbinella concentrica* Reeve, Conch. Icon., Vol. 4, *Turbinella*, July, 1847, sp. 2, pl. 1, fig. 2. "Hab. St. Elena, West Columbia (in sandy mud at the depth of seven fathoms); Cuming."—Tryon, Man. Conch., Vol. 3, 1881, p. 90 (in text), pl. 68, fig. 142 (as *Latirus concentricus*).

³Strong, A. M., and Hanna, G. D., Proc. Calif. Acad. Sci., Ser. 4, Vol. 19, No. 2, June 4, 1930, p. 11.

⁴*Ranella anceps* Lamarck, Hörnes, Abhandl. K. K. Geol. Reichsanst., Bd. 3, No. 3, 1856, p. 213, pl. 21, figs. 6a, 6b, 6c, 6d. "Steinabrunn." Austria. Miocene.

⁵See *Ranella (Argobuccinum) emmæ* Boettger. Boettger, Verhandl. u. Mitt. Siebenbürg. Vereins f. Naturwiss. zu Hermannstadt, Bd. 54, Jahrg. 1904, 1906, Gastropoda, p. 40.

⁶*Eupleura subanceps* d'Orbigny, Cossmann & Peyrot, Act. Soc. Linn. de Bordeaux, Vol. 74, Conch. Neog. de L'Aquitaine, Vol. 4, Livr. 2, Gastropoda, 1924, p. 524, pl. 12, figs. 24, 25.

of France, described as *Ranella subanceps* d'Orbigny, to the genus *Eupleura*. They mentioned that the species from the Miocene of Poland cited as *Aspella anceps* by Friedberg⁷ may not be referable to *Eupleura*. Illustrations of the Polish species indicate that it is not referable to the one described by Lamarck.

Dall, 1889, placed *Poveria* Monterosato,⁸ 1884 (not *Poveria* Bonaparte, 1841), later renamed *Dermomurex* by Monterosato,⁹ in the synonymy of *Aspella*. Woodring¹⁰ however, regarded it as a separate genus. The type species *Poveria scalarina* Bivona (= *Murex scalarioides* Blainville) has been recorded from Miocene to Recent in the Mediterranean region and in the West Indies.¹¹

Two species of *Aspella*, *A. erosa* Broderip and *A. pyramidalis* Broderip, have been described from west American waters. The latter also has been recorded by the present authors as occurring in the Pleistocene of the Galapagos Islands. *Aspella pyramidalis* is similar to *A. anceps* Lamarck whereas *A. erosa* Broderip¹² is similar to the species described as *Murex alveatus* Kiener,¹³ 1843, generally believed to be an east American species, and other forms from that region cited by M. Smith¹⁴ under the names of *Aspella scalaroides pauperulus* C. B. Adams, 1850, and *A. scalaroides obeliscus* A. Adams, 1853.

Kiener's species is now generally referred to the genus *Aspella*. It was originally described without information as to the locality from which it came. According to Tryon and others it occurs in the Caribbean region.

⁷*Aspella anceps* Lamarck. Friedberg, Moll. Mioc. Poloniae (Lwów i Poznań). Gastropoda and Scaphopoda, Pars 2, 1912, p. 182, pl. 11, fig. 16a, b, "Miejscowść: Zborów (3 ok.)."

⁸*Poveria* Monterosato, Nom. Gen. e Spec. Conch. Medit., 1884, p. 113. "Tipo: la specie seguente" (that is) "*P. scalarina*, Bivona (*Murex scalarinus*)."⁹ In the synonymy the following were included, "*M. scalaroides*, Bl. (non *Fusus scalaroides*, Lk., 1818-22)," "*Murex distinctus*, (De Crist. e Jan. 1832, foss.)," and "*M. leucoderma*, Sc."

⁹*Dermomurex* Monterosato, Natural. Sicil., Vol. 9, 1890, p. 181. A new name for *Poveria* Monterosato, 1884 (not *Poveria* Bonaparte, 1841).

¹⁰Woodring, W. P., Carnegie Inst. Washington, Publ. 385, 1928, p. 291.

¹¹*Aspella scalarioides* Blainville, Maury, Bull. Amer. Paleol., Vol. 5, No. 29, Pt. 1, April 7, 1917, p. 268 (104), pl. 43 (17), fig. 11. Miocene of Santo Domingo.

¹²*Murex erosus* Broderip, Proc. Zool. Soc. London for 1832, p. 174 (issued January 14, 1833). "Hab. ad Panamam." "Found under stones."—Sowerby, Conch. Illustr., *Murex*, Cat., p. 7, 1841, pl. 60, fig. 16, June 15, 1834.—Reeve, Conch. Icon., Vol. 3, *Murex*, 1845, sp. 160, pl. 32, fig. 160. Original locality cited.—Tryon, Man. Conch., Vol. 2, 1880, p. 129, pl. 38, figs. 460, 468.

¹³*Murex alveatus* Kiener, Spéc. Gén. Icon. Coq. Viv., Fam. Canalifères, Pt. 3, *Murex*, 1843, p. 94, pl. 46, fig. 2, "Habite."

¹⁴Smith, M., Illustr. Catal. Rec. Spec. Rock Shells (Trop. Labor.: Lantana, Florida), 1939, p. 18, pl. 14, figs. 2 and 3. For an illustration of the type of *Murex pauperulus* C. B. Adams see Clench, W. J., and Turner, R. D., Occ. Papers on Moll. Dept. Moll. Mus. Comp. Zool. Harvard Univ., Vol. 1, No. 15, June 26, 1950, p. 323, pl. 39, fig. 16. "Jamaica."

Another west American species, *Murex peasei* Tryon,¹⁵ possibly may be referable to *Aspella*. According to Pease who first described it under the name of *Murex foveolatus* (not *Murex foveolatus* Hinds, 1844), it resembles *Murex alveatus* Kiener more than any other species.

A species from an unknown locality, said to belong to the *Murex alveatus*, *peasei* group, was described by F. C. Baker¹⁶ under the name of "*Ocinebra rubra*."

ASPELLA BAKERI Hertlein & Strong, new species

Plate 26, Figures 1 and 2

Shell small, fusiform, rough; nucleus very small, white, of about 2 smooth, flattened whorls; normal whorls 5, pale brownish, darker on portions of the summit of the spiral cords and axial ribs; axial sculpture consists of 7 strong ribs extending from suture to suture and over the base to the canal; spiral sculpture consists of 2 major spiral cords on the lower portion of the whorls, riding over the axial ribs and slightly nodulous at the intersections, entire surface of spire and base with fine, raised spiral threads; canal short, nearly roofed over; aperture oval, small, outer lip flattened on the face, greatly thickened and expanded, at one half turn back from this the position of a previous lip is indicated by a decided thickening of the rib at that point, the two giving the shell the appearance of being laterally compressed, columella smooth, strongly curved. Dimensions of the type: length, 17.7 mm.; maximum diameter, 7.7 mm.

Holotype, No. 5893, paratype No. 5894 (Calif. Acad. Sci. Dept. Paleont. Type Coll.), from Loc. 24100 (C.A.S.), Agua Verde Bay, Lower California, Mexico, in the Gulf of California; Fred Baker coll.

The species here described as new is quite different in general appearance from the other species of *Aspella* occurring in west American waters. It slightly resembles *Aspella pyramidalis* Broderip¹⁷ but differs in the less flattened form, stronger radial plications between the varices and in the presence of two strong spiral ridges on the periphery of the whorls.

¹⁵*Murex peasei* Tryon, Man. Conch., Vol. 2, July 6, 1880, p. 129, pl. 38, fig. 462. "La Paz, L. California." A new name for *Murex foveolatus* Pease, Amer. Jour. Conch., Vol. 5, Pt. 2, October 7, 1869, p. 83, pl. 8, fig. 3. "Hab.—La Paz, in sinu Californico." Not *Murex foveolatus* Hinds, 1844.

¹⁶Baker, F. C., Proc. Rochester Acad. Sci., Vol. 1, Brochure 2, 1891, p. 134, pl. 11, figs. 6, 7. "Habitat unknown."

¹⁷*Ranella pyramidalis* Broderip, Proc. Zool. Soc. London for 1832, p. 194 (issued March 13, 1833). "Hab. ad Uliteam et Panamam." "Found on the reefs."—Sowerby, Conch. Illustr., *Ranella*, index to figs. (p. 7), ?1841, pl. 84, fig. 2, September 15, 1835. "Panama."—Reeve, Conch. Icon., Vol. 2, *Ranella*, 1844, sp. 43, pl. 8, fig. 43 (as *Ranella anceps*). "Hab. Panama (found on the reefs); Cuming."—Hertlein & Strong, Proc. Calif. Acad. Sci., Ser. 4, Vol. 23, No. 24, 1939, pp. 369, 379, pl. 32, figs. 10, 13 (as *Aspella pyramidalis*). James (San Salvador) Island, Galapagos Islands, Pleistocene.

MARGINELLA WOODBRIDGEI Hertlein & Strong, new species

Plate 26, Figures 3 and 4

Shell ovate, smooth, bright and shining; slate-colored with two poorly defined narrow darker bands dividing the shell into thirds; nucleus of a little more than 1 whorl, forming a small, pale orange-colored, flattened apex to the shell; normal whorls 2, sutures channeled, edged with white and bordered with a very fine orange-colored line; aperture narrow, nearly as long as the shell, outer lip thickened, blunt, white on the face with a fine orange line behind it; columella with 4 strong white plications, orange in the interspaces, interior of the aperture brown. Dimensions of the type: length, 12.3 mm.; maximum diameter, 7.2 mm.

Holotype, No. 7253, paratype No. 7254, from Loc. 29042 (C. A.S.), San José, Guatemala; Woodbridge Williams collector, April, 1937.

This new species appears to be the one reported from west American waters in older records under the name of *Marginella marginata* Born,¹⁸ a somewhat similar shell from the West Indies. The west American shell differs from the species described by Born in that the shell is more slender, less broadly rounded across the shoulder and the outer lip is narrower.

This new species greatly resembles the illustration given by Sowerby¹⁹ of a shell from Panama cited as "a dwarf variety" of *Marginella cærulescens* Lamarck,²⁰ a species originally described from "sur les côtes de l'île de Gorée," Africa. Redfield and Tryon questionably referred Sowerby's figure 155 to *Marginella storeria* Couthouy²¹ which was originally described from the Gulf of Mexico. Tomlin²² later stated that the form illustrated by Sowerby's figure 155 is not referable to *M. cærulescens* and mentioned Redfield's conclusion regarding it. Lamarck's species is now generally placed in the synonymy of *Marginella prunum* Gmelin, 1790, a species in which the spire is much higher than that of *M. marginata* or *M. storeria*. The species here described as new more closely resembles *Marginella storeria* Couthouy than any other species known to us but differs in possessing a narrower shell, more sloping shoulder of the body whorl and in the narrower outer lip. The orange-colored line behind the outer lip is a characteristic feature of *M. woodbridgei*, but in bleached shells the shape serves to separate it from other west American species.

¹⁸*Voluta marginata* Born, Index Cæs. Vindobon., 1778, p. 207.—Born, Test. Mus. Cæs. Vindobon., 1780, p. 220, pl. 9, figs. 5, 6. "Patria ignota."—Reeve, Conch. Icon., Vol. 15, *Marginella*, 1864, sp. 46, pl. 11, figs. 46a, 46b. "Hab. Senegal, West Africa."

¹⁹*Marginella cærulescens* Lamarck, Sowerby, Thes. Conch., Vol. 1, 1846, p. 383, pl. 77, fig. 155. "From Panama. Fig. 155 represents a dwarf variety."

²⁰*Marginella cærulescens* Lamarck, Hist. Nat. Anim. s. Vert., Vol. 7, August, 1822, p. 356. "Habite l'Océan atlantique, sur les côtes de l'île de Gorée."

²¹*Marginella storeria* Couthouy, Boston Jour. Nat. Hist., Vol. 1, No. 4, May, 1837, p. 440, pl. 9, figs. 1, 2. "Inhabits the southern coasts of the Gulf of Mexico."

²²Tomlin, J. R. le B., Proc. Malacol. Soc. London, Vol. 12, 1917, p. 256.

SOME FOSSIL INSECTS FROM A NEVADA HOT SPRING DEPOSIT

By IRA LA RIVERS

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During 1945, Mr. J. B. Palmer of Reno, Nevada, then stationed at the Army Air Base some 14 miles northwest of Reno, dug some siliceous sinter containing casts and molds of a large insect from a dried spring hole at Steamboat Springs, 11 miles south of Reno. He presented his find to the Department of Geology of the University of Nevada, and in the course of time, the material came to me. I must thank Dr. Harry E. Wheeler, then with the department, and now at the University of Washington, for first calling it to my attention. Dr. Vincent P. Gianella and Prof. Walter E. Palmer, Sr., of the Mackay School of Mines, University of Nevada, gave me additional material and information concerning the find.

In many years of searching, this is the first instance of insect fossilization in Nevada that has come to my attention. It is possible, in some thermal situations in the State, to see what appears to be the prelude to insect preservation, where specimens may be flying into hot pools in great numbers, being almost immediately scalded, and some eventually sinking to the bottom where the heavily impregnated waters immediately begin to deposit salts on the carcasses (La Rivers & Trelease 1941). Quite obviously, such happened at the Steamboat Springs locality.¹

The occurrence of such well-preserved fossil material at Steamboat merely serves to add to the distinctiveness of the Springs, which already have considerable fame among geologists as an unique natural laboratory for the study of ore deposition by hot waters, and as one of the three natural geyser areas in the United States: Brannock, Fix, Gianella and White (1948) have presented a recent geologic and chemical analysis of the Springs, to which I am indebted for many of the salient points mentioned below.

Steamboat Springs is a unit of some 50 hot springs of volcanic origin, situated at the northeast edge of the Steamboat Hills and occurring in a small ridge of siliceous sinter deposited by the hot waters on the valley alluvium. The elevation is approximately 4600 feet. According to Brannock et al, "The springs appear to be structurally related to recent faults and genetically related to the magmatic source of the recent volcanic domes of pumiceous

¹Pierce (1950) has some preliminary remarks on hot spring fossilization.

rhyolite" (p. 211). Present day temperatures of the discharging waters (springs and wells) range from boiling for this altitude (95.5°C) to 43.3°C , in most cases. Temperatures as high as 137.7°C were found below the surface.

As might be expected, the waters are highly charged, possessing 2000 to 2500 parts per million of mineral matter, mostly sodium, chloride, carbonate, bicarbonate, silicon dioxide, sulfate, and considerable boron. The natural spring discharges are actively precipitating siliceous sinter with some calcium carbonate. The springs have also deposited cinnabar, pyrite, stibnite, gold and silver, while metallic mercury precipitates out from some of the vapors. The siliceous sinter seems to be mainly opal, with a substantial amount of chalcedony and smaller quantities of quartz. "Most of the sinter, as far as could be determined, was formed by the drying of siliceous muds and by the direct precipitation of silica from the water, probably as a result of evaporation. Both of these processes are occurring at the present time near the active springs" (Brannock et al). They regard the oldest sinter as "probably middle or late Pleistocene" in age. It does not seem

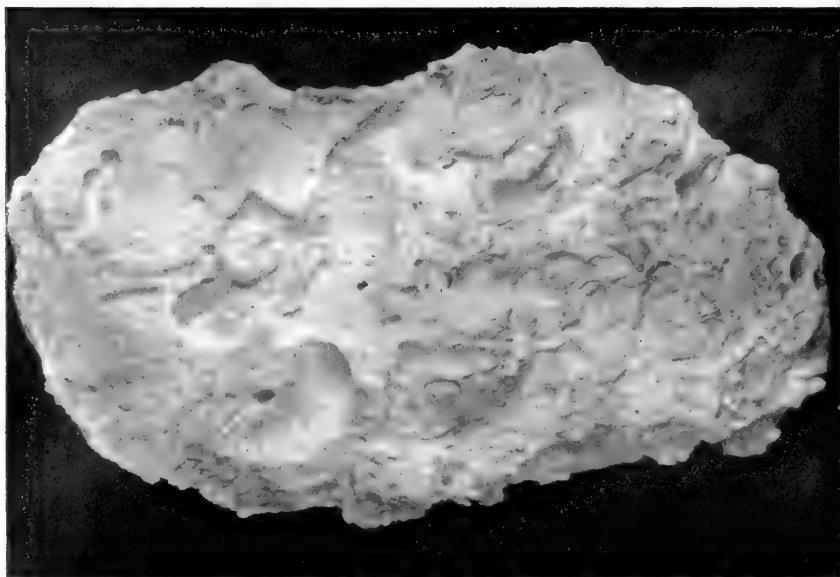


PLATE 27

A block of siliceous sinter filled with casts and molds of the Mormon cricket, *Anabrus simplex*. Most of the impressions are those of abdomens. X $2\frac{2}{3}$ rds.



PLATE 28

View of left side of an exceptionally good cast of an adult *Anabrus simplex*. The eye facetations of this specimen are readily observable under moderate magnification. X 3.6.

possible to date the insect material as anything but late Pleistocene, at the oldest, since it is superficial for the most part. By the same token, it might well be Recent in age.

A large portion of the original sinter deposit seems to have been later reworked to a considerable degree by hot waters after being buried under younger sinter; as a consequence, opal, chalcedony and quartz have secondarily been deposited in the interstices of the original opal, chalcedony and quartz sinter. Where deposition was due to precipitation out of solution, a friable sinter was produced; where deposition occurred as replacement of organic tissues, animal or plant, it was frequently productive of a much stonier, more compact and lustrous form of silicon dioxide, evidently chiefly opal with some chalcedony. This is apparent in the blocks of material containing the best insect casts and molds; the casts are composed of this compact type of SiO_2 , embedded in the more porous, friable sinter.

As yet, only the two following types of insects have been identified from the Steamboat Springs material. Plant remains are very common in some sections of the older sinter deposits.

Order ORTHOPTERA

Family TETTIGONIIDÆ

ANABRUS SIMPLEX Haldeman 1852. The Mormon Cricket

The entire material from the dried spring hole on the sinter terrace proper is all representative, as nearly as can be determined, of this species. Some excellent casts are present, and it is possible to reconstruct the animal beyond little reasonable doubt as far as its identification is concerned. Certain blocks dug from the type spring indicate that a moving band of crickets piled up in great numbers in the hot water, being preserved literally stacked one on the other. In size, the insects ranged from adults to last instar nymphs; replacement is faithful enough to show the most minute external details, such as eye facetation. In a good many cases, casts are broken in such a way as to show that a great deal of the internal structure has been minutely replaced.

While the Mormon cricket does not, apparently, now occur in the Truckee Meadows, it ranges comparatively close to the area, which is entirely suitable for it. The dominant local tettigoniid

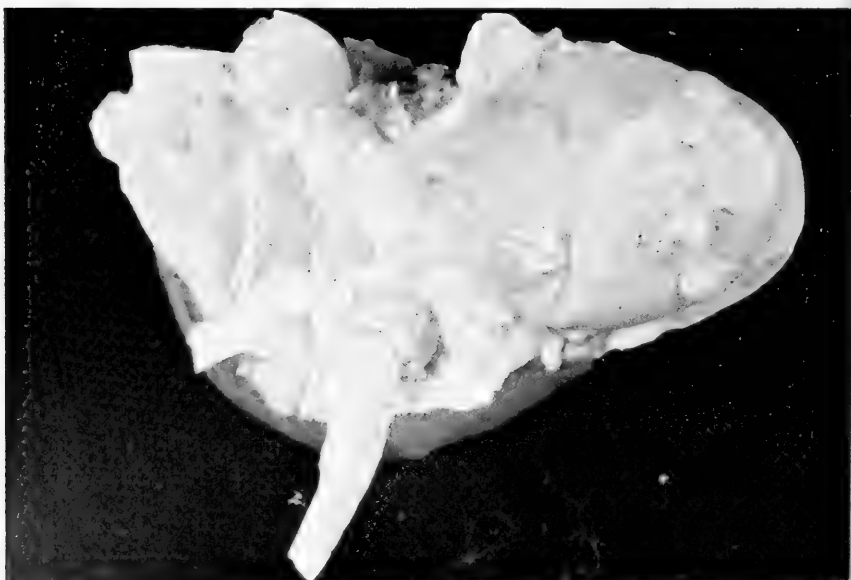


PLATE 29

Face view of the same specimen shown in Plate 28. Details of the mandibles, as well as those of the thoracic, and a portion of the abdominal, venter, are quite well preserved. X 4.

of comparable size, *Idiostatus elegans* Caudell 1907, itself only sporadically common, is somewhat smaller and with different proportions, but likewise has the habit of congregating in bands at certain times of the year.

Order COLEOPTERA

Family CURCULIONIDÆ

CALENDRA sp.

A weevil, seemingly referable to this genus, was found in older, unsolidified and unconsolidated siliceous sinter at the south-east edge of the sinter terrace during a visit by the author in 1946. This type of sinter is dark, and seems to have been largely a siliceous mud. The genus *Calendra*, with several species in the vicinity of Steamboat Springs (most common of which are *Calendra graminis* (Chittenden) 1906 and *C. mormon* (Chittenden) 1904), is partial to the proximity of water.

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A NEW SPECIES OF *LIMNORIA* (Crustacea: Isopoda) From Southern California

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Los Angeles 7, California

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Since a year or more must elapse before the publication of the writer's monograph on the species of *Limnoria* of the world, including a full treatment of their synonymy and distribution, it is felt desirable at this time to describe a new species of wood-boring *Limnoria* which occurs in southern California in order that current ecological and parasitological studies by my colleagues having this species as their basis may not be retarded unduly. Reference will, therefore, be made only to the species as it is present locally, although it is known to attain world-wide distribution and to have considerable economic importance because of its ability to bore into creosoted wood.

LIMNORIA TRIPUNCTATA new species

Plate 30

Synonyms. *Limnoria lignorum* (Rathke), Mohr & LeVeque, 1948, p. 26 (Newport reference).—Richardson, 1899, pp. 821-822 (H. Hemphill's specimens);—1905, p. 269 (San Diego reference).

Diagnosis. Scale of first antenna not conspicuous. Flagellum of second antenna with five articles. Epipod of maxilliped tri-angulate, two and one-half times as long as wide, and just reaching the articulation of the palp with endopod. Mandibular palp with three articles. Mandible with "rasp" and "file" incisive processes. Fifth somite of pleon medially with two posteriorly located elevated swellings and a single anteriorly located swelling on dorsal surface; central part depressed. Telson medially with one anteriorly located tubercle followed by a pair of tubercles on dorsal surface; paired tubercles each followed by a longitudinal carina. Posterior margin of telson tuberculate; lateral crests of telson tuberculate. Lacinoid seta of right mandible abruptly curved distally, apex spinulate.

Measurements. Holotype male length, 2.0 mm., width of telson at widest point 0.6 mm. Allotype length 2.4 mm., width of telson 0.6 mm.

Type locality. A type series consisting of 44 specimens was collected by Mr. and Mrs. R. J. Menzies on December 23, 1948 from a redwood ladder located on the edge of Mission Bay at the

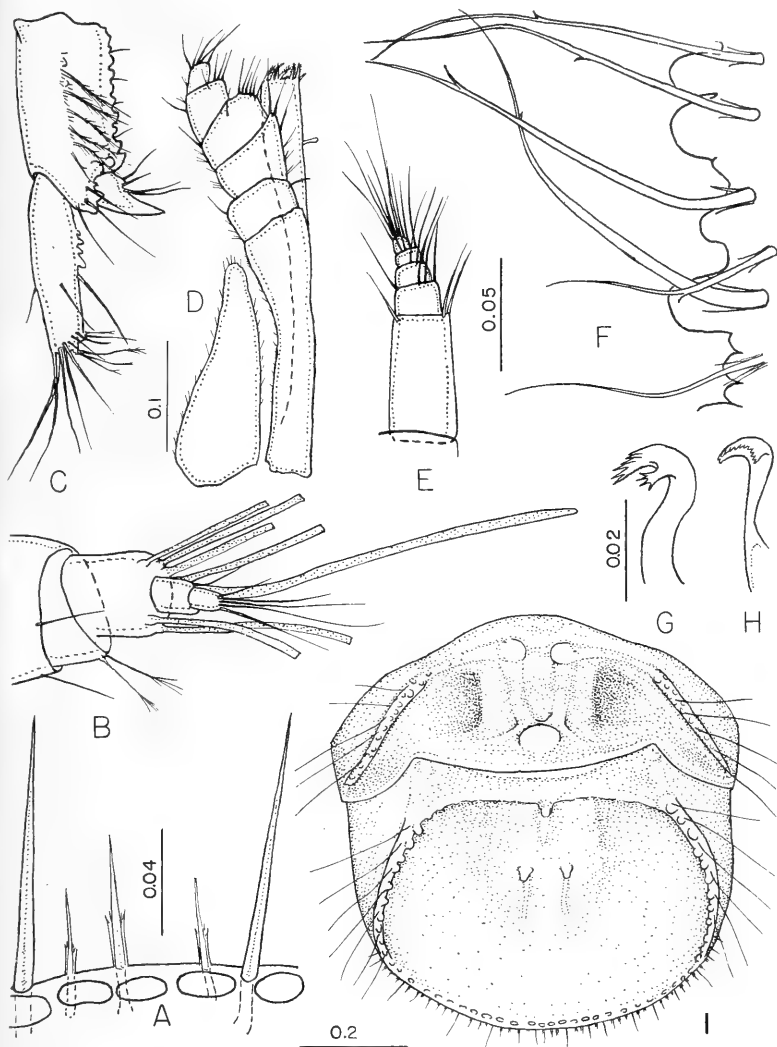


PLATE 30

LIMNORIA TRIPUNCTATA, new species

Male paratype

a, posterior edge of telson. *b*, distal articles of first antenna. *c*, uropod. *d*, maxilliped. *e*, flagellum of second antenna. *f*, lateral crest of telson. *g-h*, lacinioid seta of right mandible. *i*, dorsal view of fifth somite of pleon and of telson. Figures with similar magnifications as indicated by mm. scale: *a*; *b*, *e*, *f*; *c*, *d*; *g*, *h*; *i*.

foot of Fanuel Street, Pacific Beach, San Diego Co., California. A second series consisting of over 100 specimens was received as a loan from Dr. Fenner A. Chace Jr., Curator of Marine Invertebrates, United States National Museum. These specimens had been collected by Dr. H. Hemphill from San Diego, California and had been identified by various investigators as *L. californica* Hewston, a nomen nudum, and *L. lignorum* (Rathke) (Richardson, 1905, p. 269). I have designated Hemphill's specimens as additional paratypes of the species.

Location of types. Type specimens have been deposited in the collections of the following institutions: United States National Museum, Washington 25, D. C., holotype, allotype, and 25 paratypes plus an excess of 100 paratypes from the Hemphill collection (Cat. No. 2286 USNM); Allan Hancock Foundation, University of Southern California, Los Angeles 7, California, 2 male, 2 female paratypes; British Museum (Natural History), London, 2 male, 2 female paratypes; Rijksmuseum van Natuurlijke Historie, Leiden, Holland, 2 male, 2 female paratypes.

Specimens examined. In addition to the types, specimens were examined from the following localities: *Newport Bay*, Orange Co., upper part of bay, February 14, 1950, R. J. Menzies, 100 specimens (in creosoted wood); at bridge, U. S. Highway 101, February 14, 1950, R. J. Menzies, 100 specimens; at overpass, U. S. Highway 101, April 17, 1947, J. L. Mohr and A. LeVéque, 50 specimens. *Catalina Island*, July 15, 1950, Allan Hancock Foundation, over 100 specimens (from creosoted piling). *La Jolla*, San Diego Co., August 16, 1949, R. J. Menzies, 25 specimens (with *L. quadripunctata* Holthuis).

Remarks. This species differs from *L. lignorum* (Rathke) and *L. quadripunctata* Holthuis in having three tubercles on the dorsal surface of the telson. In *L. lignorum* no tubercles are present, whereas, in *L. quadripunctata* there are four (Holthuis, 1949, pp. 167-172).

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AN UNUSUAL HABITAT FOR *ZIRFÆA PILSBRYI*
(Mollusca: Pelecypoda)

By WILLIAM K. EMERSON

The Allan Hancock Foundation recently received a portion of a log containing two burrows of the bivalve *Zirfæa pilsbryi* Lowe² with a clam *in situ*. Since this appeared to be a previously unrecorded ecological occurrence of this species, further information regarding the habitat was requested from the collector, Lee O. Miles, of Oakland, California.

The data supplied disclosed that a bed of gray clay in which several trees and many pine cones are imbedded is situated in Campbell Cove, Bodega Bay, California. The bed is located in the harbor near the entrance to the outer bay in a natural channel and is covered by water except at low tide. The remains of the trunks, while partially decomposed, still retain their original characteristics with the exception of being softer due to water permeation. Specimens of *Zirfæa pilsbryi* which are living in the clay, apparently bore into the wood by chance rather than by choice. Some of the bivalves appear to be living in burrows which are confined entirely to the logs that are exposed at the surface of the clay bed.

The piece of log which was cut free measures 8.5 inches in greatest diameter and 9.5 inches in length. The smaller burrow, which is 2.5 inches at its greatest diameter and 2.25 inches at the smaller end, contained a living clam at the time the segment was removed. The anterior portion of the clam is shown in the burrow, plate 31, figure 1. The larger burrow, which was not occupied, measures 2.75 inches in diameter.

The boring process of the species appears to be extremely effective in wood as well as in hard clay. G. E. MacGinitie describes in detail the boring movements of this species in his paper on the fauna of Elkhorn Slough.³ The specimen removed from the burrow, plate 31, figure 2, possesses valves measuring over 3.5 inches in length. There appear to be no major differences between specimens living in the clay and in the wood.

To the writer's knowledge, the only other record of *Zirfæa* burrowing in a medium other than its natural habitat, "hard" clay, was reported in a personal communication⁴ to him by William

¹Contribution no. 64 of the Allan Hancock Foundation, The University of Southern California.

²This species was formerly known as *Zirfæa gabbi* Tryon.

³G. E. MacGinitie, American Midland Naturalist, vol. 16, no. 5, pp. 731-735, 1935.

⁴In *litteris*, November, 1949.

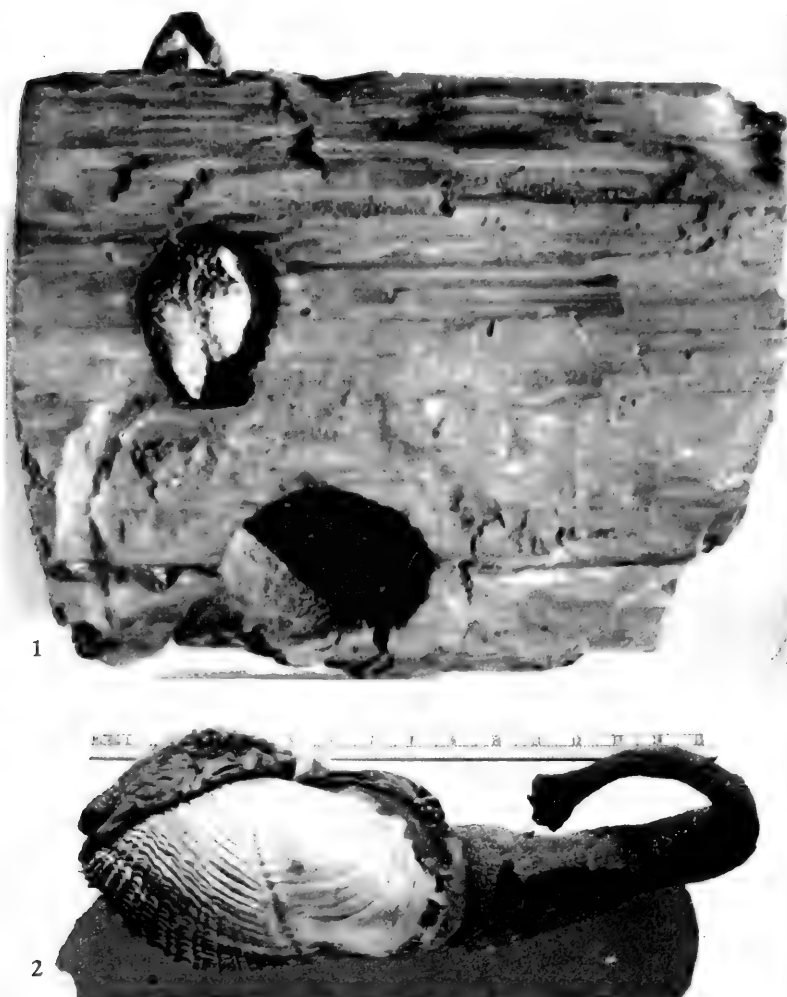


PLATE 31

EXPLANATION OF FIGURES

Figure 1, a segment of the log showing a specimen of *Zirfaea pilsbryi* *in situ* and an unoccupied burrow.

Figure 2, *Zirfaea pilsbryi*, lateral aspect of the left valve, specimen removed from the burrow.

(Photographs by J. D. Soule, Allan Hancock Foundation)

J. Clench, Curator of Mollusks, the Museum of Comparative Zoology, Harvard College. He found the Atlantic coast representative of the genus, *Zirfæa crispata* (Linné), burrowing in association with *Petricola pholadiformis* Lamarck in a consolidated peat moss bed located in the intertidal zone on an exposed beach near Situate, Massachusetts.⁵

The possible economic significance of *Zirfæa* as a wood destroyer will remain questionable until actual tests can be conducted. It is a matter of conjecture whether untreated piling vertically sunk in a clay bank containing *Zirfæa pilsbryi* would be damaged by the borings of these bivalves. It seems probable that any penetration of the piles would be accidental to the location and direction of the burrows.

⁵The Clapp Laboratory recently discovered 15 specimens of *Zirfæa* in a wooden test block removed from Buzzards Bay, Massachusetts, U. S. Bureau of Docks and Harbors, p. 38, 1950.



NOTES ON THE BIOLOGY OF TRICRANIA STANSBURYI HALDEMAN (COLEOPTERA, MELOIDÆ)

By E. G. LINSLEY and J. W. MACSWAIN

University of California, Berkeley

Tricrania stansburyi Haldeman is a widely distributed but uncommonly encountered nemognathine meloid. We have seen material from scattered localities along the Pacific Coast from British Columbia to southern California and from the Rocky Mountain region as far south as Colorado. From our observations it would appear that its relative rarity is largely a reflection of biological characteristics which tend to minimize the likelihood of its being seen by the field collector.

The biology of *Tricrania sanguinipennis* Say, as a parasite of *Colletes rufithorax* Swenk and *C. inequalis* Say in eastern North America, has been discussed by Parker and Böving (1924) and will not be reviewed here. It is the purpose of the present paper simply to place on record some of the varied host relationships of *T. stansburyi* and to call attention to a few observed features of its biology as a basis for comparison with *T. sanguinipennis*. A third species, *T. murrayi* LeConte, was described from a single specimen from Oregon. In California we have found three additional examples, crawling on grass stems in an open field. As yet nothing is known of its biology.

T. stansburyi has been recorded by Hicks (1926) from the nests of *Hoplitis cylindrica* Cresson and *H. producta* Cresson and has been reared by us from the cells of three additional genera of solitary nesting bees. In addition, the first instar larvæ have been found on adults of other species and genera of bees of similar habit which might possibly serve as hosts. The rearing records are as follows: *Osmia densa pogonigera* Cockerell (Plate 32) (2 ♀, 1 ♂, from cell series in old beetle burrows in slab of yellow pine bark lying on ground, Miami Ranger Station, Mariposa Co., California, V-17-1942, E. G. Linsley), *Anthidium edwardsii* Cresson (1 ♂ from cell series in flat ground, Mt. Diablo, Contra Costa Co., California, V-23-1940, J. W. MacSwain), *Anthophora edwardsii* Cresson (1 ♂, 1 ♀, from cell series in bank, Somersville, Contra Costa Co., California, II-15-1947, E. G. Linsley, J. W. MacSwain, R. F. Smith). The larval records include: *Osmia* spp. (Hat Creek, Shasta Co., California, VI-1-1941, VI-3-1941), *Osmia* sp. (3 mi. N. of Hat Creek, Shasta Co., California, flowers of *Phacelia*, VI-5-1941, P. D. Hurd, Jr.), and *Hoplitis* (*Monumetha*) *albifrons maura* (Cresson) (3 mi. N. of Hat Creek, Shasta Co., California, P. D. Hurd, Jr.



PLATE 32

Cell series of *Osmia densa pogonigera* Cockerell with unemerged adult bees, and the parasitic beetle *Tricrania stansburyi* Haldeman *in situ*.

Our rearing records, together with data from field-collected specimens, indicate that the larvæ pupate either in the fall or very early spring and that adults emerge in March, April, or May, depending upon the latitude and elevation.

After emergence, mating probably takes place in the immediate vicinity of the nesting site. Although males have been taken in flight on rare occasions we have never observed flight in females (*T. sanguinipennis* is flightless in both sexes). The act of copulation was observed once in the laboratory and required about five minutes for completion. However, this case may have been atypical since the male and female had been removed from bee cells about a month earlier than they would normally have appeared. Following copulation, the male and female remained inactive within their cage without accepting any food, including pollen and nectar, which was offered. After two weeks the male died. The female, maintained under similar conditions, survived for two and one-half months. Slightly more than two months after the single act of copulation the female laid a few eggs, both singly and in small groups, near or under small pieces of earth. Although some of these eggs failed to mature most of them hatched after an incubation period of 16 days. A few days later the larvæ were removed and killed for larval studies and no information on their longevity was obtained. Field collections of larvæ on bees indicate that they are active in the field by early June (northern California).

Certain general field observations might suggest the normal oviposition habit. Since emerged adults of this species are most commonly collected crawling on fence-posts, logs or dead trees, it is probable that the eggs, unlike those of the closely related genus *Hornia* (Linsley & MacSwain, 1942), are normally laid near, but probably not in, the burrows of their hosts. This assumption is further supported by the small numbers of larvæ, from one to three, found on any one host bee. In the case of *Hornia*, which lays its eggs in the burrow of the host, 50 or more larvæ may be attached to a single adult bee. It is also probable that the larvæ attach themselves to the hairs of the host bee when the host rests on the surface near an oviposition site. This conclusion is suggested both by the nesting habits of the known hosts and because such a method occurs in the related eastern species. All known host bees nest either in the ground or near the ground; the observed carriers of larvæ nest in the ground, in burrows in dead wood or bark, or in hollow stems of pithy shrubs. In all cases the bees concerned spend much time on the ground where actual infestation by larvæ most likely occurs.

In the three instances where this species was reared, the contents of each cell containing an adult *Tricrania* was carefully examined and no larval fragments of bees were discovered. From

this it may be assumed that the parasitic larva follows the normal pattern of *Nemognatha* spp., *Tricrania sanguinipennis* and *Hornia* spp., by first destroying the egg of its host and then feeding on the stored pollen and nectar.

In each observed case the beetle was found to have consumed the contents of a single cell, pupated within that cell and completed its cycle in one year. Adult specimens exhibit marked size variation, probably correlated with the amount of stored pollen available since the host bees show a similar size variation from species to species.

In general, the few known facts concerning the habits of *T. stansburyi* parallel those of the eastern *T. sanguinipennis*. Such differences as are now known are due to the reduced wings of the latter species and the apparent wider host tolerance of the former. At the present time *T. sanguinipennis* has been recorded only from the cells of two species of bees of the genus *Colletes*.

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A NEW SUBSPECIES OF *MITOURA SIVA* EDWARDS

By J. W. TILDEN

San Jose State College, San Jose California

Butterflies of this species taken about seven miles west of Simmler, San Luis Obispo County, California, seem to represent a hitherto undescribed subspecies, for which the following name is proposed:

MITOURA SIVA MANSFIELDI, new subspecies

Holotype male: Upper surface, medium rich brown, darker on the costa and margins; marginal line brownish black. Upper wings with reddish brown (nearly chestnut) submarginal shadings between veins from Cu_1 to posterior margin; stigma well-developed; hind wings with reddish brown dash before Cu_1 ; submarginal lunules of the same color between veins Cu_1 to 2nd A, and with an anal dash of the same color. A fine white submarginal line between veins Cu_2 and 2nd A; tails short, slender, at ends of veins Cu_1 and Cu_2 , these tails fragile (and at times in some specimens, marked by short projections only).

Lower surface: Forewings, rufous ground color heavily overlaid with green (nearly grass green) scaling on costa and wing tip, the scaling extensive and tending to obscure the ground color except in the vicinity of the submarginal line, which is white and composed of (five to seven) dashes, the first three from R_5 to M_2 vertical and nearly in line, the two from M_2 to Cu_1 slightly nearer the outer margin, and the remaining two (when present, as they are in the holotype) much thinner and slanted diagonally basad; Submarginal line dusted internally with a very few dark scales.

Posterior wings: Green scaling very heavy, totally obscuring ground color so that surface appears solidly green; macular band white, inlaid internally with a deep brown line of equal or slightly greater width, this brown line sharply delimited and not extending basad as a broad shade. Macular band bisinuate, the vertical dashes between R_1 and R_s and between M_3 and Cu_2 nearer the outer margin. A submarginal row of four blackish spots from below M_2 to below Cu_2 ; between these submarginal spots and the thin white marginal line there is a series of irregular gray shades of intermingles black and white scales. Expanse, 24 MM.

Allotype female: Similar in coloration and maculation to the male, but upper surface reddish brown with dark borders. Expanse, 25.5 MM.

Both sexes: Body grayish brown, lighter below; legs annu-



PLATE 33

TOP FIGURE: *Mitoura siva juniperaria* Comst., Topotype, Summit of Mint Canyon, Los Angeles County, Calif. (reared), emerged March 24, 1945, J. A. Comstock, collector.

BOTTOM FIGURE: *Mitoura siva mansfieldi*, new race. Holotype, seven miles west of Simmler, San Luis Obispo County, Calif., March 21, 1940, J. W. Tilden, collector.

Figures enlarged X $3\frac{1}{3}$.

lated black and white; antennae annulated black and white, the terminal sensory depression rufous.

From *M. siva siva*, which it closely resembles, *M. siva mansfieldi*, new subspecies, differs in smaller size and more regular macular band on the under surface of the secondaries. In *M. siva siva*, this band is notably contorted and the dashes composing it may be curved. In *M. siva mansfieldi*, the dashes composing the macular band are nearly straight, the band merely bisinuate. *M. siva siva* has more extensive ornamentation on the anal area of the under surface of the hind wing than has *M. siva mansfieldi*.

From *M. siva juniperaria*, *M. siva mansfieldi* differs by its darker color on the upper surface, particularly in the male; by its slightly larger size; by the much greener coloration of the lower surface and by the lack of the broad brown shading internal to the macular band of the lower surface of the secondaries. The general appearance of *M. siva mansfieldi* is brown above (in the male) and green below, with neat sharp white maculation. *M. siva juniperaria* appears grayish brown above, mixed reddish brown and greenish below, and with much more diffuse maculation.

Type material: Holotype male and allotype female, seven miles west of Simmler, San Luis Obispo County, California, which is here designated as the type locality, March 21, 1940; eleven designated paratypes, all from the same locality, some taken March 21, 1940 and some taken April 14, 1951.

Type material distributed as follows: Holotype male and allotype female in the collection of the California Academy of Sciences, San Francisco, California; one male and one female paratype in the collection of the Southern California Academy of Sciences, Los Angeles, California; one male and one female paratype in the collection of Mr. H. A. Freeman, Garland, Texas; the remainder in the collection of the author.

This subspecies seems rather scarce; two trips to the area in 1951 yielded but five specimens, all taken on April 14. The insects are found associated with California Juniper, *Sabina Californica* (Carr.) Antoine. One male was found at flowers of Gold Fields (*Bæria* sp.)

It is with pleasure that this subspecies is named for Capt. G. S. Mansfield, USMC, the author's companion when the first specimens were taken.

Thanks are due to Mr. Lloyd M. Martin for the opportunity to examine a pair of topotypes of *M. siva juniperaria*, and to Mr. Lester Brubaker of San Jose State College for the superb photography.

A NEW MOTH OF THE GENUS *APICIA*
FROM ARIZONA

By CARL W. KIRKWOOD

In a recent lot of Geometrides sent to Mr. John L. Sperry for identification, a series was returned with the notation that it was probably new (unless something from Central or South America would show it up) and suggested that it be given a name.

Apicia graceiaria n. sp. Male: Color dark gray, with an overall sprinkling of yellowish scales, with the greatest concentration on the costa. That portion of the t.a. line, beyond the rather sharp angle being perpendicular to the inner margin. T.p. line slightly curved inwardly just before reaching the costal margin. T.p. and t.a. lines brown, with the t.p. line outwardly edged with yellowish. Discal spot present. The t.p. line is continued across the secondaries, with the discal spot being only slightly indicated or entirely absent. Underside: Similar to upper surface but much suffused. T.a. line is only weakly indicated. Discal spot not prominent on primaries but plainly indicated on secondaries.

Female: T.a. line more curved, not so sharply angulated as in the male. Basal area pinkish tan also the space from the t.p. line to outer margin. The median space pale yellow, in some examples this color is continued into the basal area. Discal spots black and much more prominent than in the male. T.p. line and marginal color continued across the secondaries. Over the whole the wings are finely sprinkled with black speckles, being heavier



PLATE 34

Apicia graceiaria n. sp. Holotype ♂, left; allotype ♀, right.
Figures slightly enlarged.

on the secondaries thus giving the appearance of being darker. Underside: Similar to the upper surface except more heavily sprinkled with black speckles.

Holotype: Madera Canyon, Santa Rita Mtns., Arizona. August 18, 1949.

Allotype: Madera Canyon, Santa Rita Mtns., Arizona, August 14, 1949.

Paratypes: Nineteen males and twelve females from the same locality, from July 16, to August 18, 1949. Collectors Lloyd M. Martin and C. W. Kirkwood.

The Holotype and Allotype are to be deposited in the Los Angeles County Museum. Paratypes are to be distributed as follows: Los Angeles County Museum, Mr. John L. Sperry, Riverside; Mr. W. R. Bauer, Petaluma; and the author's collection.

Named in memory of Grace H. Sperry.

At this time I wish to express my appreciation and thanks, for the help given me by Mr. John L. Sperry and Lloyd M. Martin.



NEW GERONTOGENOUS HYDROMETRIDÆ (HEMIPTERA)

By CARL J. DRAKE

Water-striders of the family Hydrometridæ are known by the appellation "marsh-treaders," and are widely distributed in both Hemispheres. This paper contains the descriptions of two new species of hydrobatids from the Orient and one from the Solomon Islands of the South Pacific. The types have been deposited as indicated beneath the descriptions of the different species.

HYDROMETRA OKINAWANA, sp. new

Brachypterous form: Small, slender, brown with head becoming darker basally. Length, 8.00 mm.

Head: Length, 2.50 mm. Antecular part scarcely more than twice as long as postocular part (64:30). Clypeus moderately broad at base, very long, nearly three times as long as width at base, smooth, dark brown, slowly narrowed from base to around apical third, then abruptly narrowed and narrowly pointedly produced forward. Ocular groove above shallow; groove beneath deeper, wider, not extending beyond margins of eyes. Rostrum brown, reaching considerably beyond middle of postocular part. Antennæ yellowish brown, the basal segment dark fuscous with the base narrowly testaceous; formula—I, 15; II, 30; III, 88; IV, 55.

Pronotum: Length, 2.50 mm. Pronotum longly deeply constricted at the middle so as to form two nearly equal lobes; median line fairly distinct, profound, not frosted; anterior lobe impunctate, with an encircling row of small pits near to and paralleling front margin; hind lobe distinctly narrower than front lobe, pitted with rather small deep pits (sometimes pits not very plainly visible without wetting surface of lobes), a row of pits in median line and two not very regular rows on each side of this line; propleura with a few small pits. Wing pads short, brown with inner margin whitish, hardly reaching to base of pronotum. Distance between fore and middle acetabula practically half as far as between middle and hind acetabula. Hind acetabula without pits. Middle and fore acetabula each with four pits, two on each side of a cleft (one specimen with three pits behind one cleft of one acetabulum).

Legs: Yellowish brown, smooth, without long hairs. Length of fore femora, 3.20 mm.; hind femora, 3.20 mm. Apex of fore

femora not reaching to base of antennæ; that of hind femora hardly attaining apex of genital segments.

Abdomen: Length, 2.32 mm. Dark brown, slightly darker on the sides, without lateral white stripes. Tergites, excepting last, reddish brown.

Male: Last venter gradually narrowed apically, shorter than preceding segment, with a pair of blackish frustum-like processes (one on each side of venter) placed near the hind margin of the segment, each process rather short, and tilted a little backwards, not impressed or smooth back of processes; first genital segment flattened a little on each side, terminating posteriorly in a short, stout, almost straight spine. Macropterous form and female unknown.

Type (male): Chizuka, Okinawa Island, July-Sept., G. E. Bohart, Calif. Acad. Sciences. Paratype (male), Taipei, Formosa Island, March 9, 1909, J. C. Thompson, in my collection. The latter lacks the last three antennal segments, and the clypeus is a little shorter than in the type.

Related to *H. jaczvskii* Lundblad, but smaller with larger male genital processes. The smaller size, shorter legs, shorter anteocular part of head and location of male processes on last segment of venter also separate *H. okinawana* n. sp. from the two species described herein.

HYDROMETRA TAIPEHANA, sp. new

Elongate, slender, brown, the tergites (save last one) reddish brown. Length, 11.00 mm.

Head: Length, 3.20 mm. Anteocular part slightly greater than twice as long as the postocular part (86:34). Interocular groove above short and shallow; groove beneath deep, wide, posteriorly extending beyond middle of postocular part. Antennæ fuscous to dark fuscous, the first segment pale basally; Formula—I, 22; II, 48; III, 104; IV (wanting).

Pronotum: Length, 1.52 mm. Median frosted line profound, extending from base to apex of pronotum; deeply and longly constricted between the lobes so as to divide pronotum into two practically equal parts; front lobe impunctate, excepting for the encircling row of pits just behind collar; hind lobe deeply pitted with a row of pits on median line and some other scattered pits on posterior part of lobe; all pits deep, not very large but easily visible. Propleura with a few pits behind acetabula. Space between fore and middle acetabula practically one-half the distance as that between middle and hind acetabula (32:62). Fore and middle acetabula each with six pits, three on each side of cleft of

an acetabulum. (Sometimes pits rather difficult to see without wetting the surface of the acetabula). Hind acetabula without pits.

Legs: Dark brown to fuscous, the tips of femora darkened. Fore femora scarcely reaching apex of head; hind femora reaching along sides of first genital segment, the posterior margin of hind femora with extremely long hairs, each hair between three and four times as long as the diameter of femora; no long hairs on basal and apical parts of segment. Length, fore femora 4.10 mm.; hind femora, 4.25 mm.

Abdomen: Length, 5.00 mm. Hemelytra straplike, barely reaching to base of abdomen, dark fuscous with veins darker, whitish along inner margin. Tergites deep brown, glabrous, the last segment roughened. Connexiva dark brown with outer margin narrowly dark fuscous. Body beneath brown with the white stripe on each side not prominent.

Male: Last segment of venter slightly more than half of the length of the preceding segment, clothed with a few scattered hairs; processes, one on each side near the middle of the segment, composed of small, raised, rounded areas topped with a dense brush of stiff bristly brown hairs, the surface of ventral segment scarcely impressed behind processes. First genital segment moderately impressed on each side, without prominent median ridge, terminating dorsally in a short, stout, slightly upturned spine.

Type (male), Taipeh, Formosa, China, March 9, 1909, J. C. Thompson, Calif. Acad. Sciences. Paratypes: male, collected with type; male, Amoy, Fukein, China, May 25, 1933, S. W. Ling. The latter is without a head.

The male processes of this species are shorter, but placed in a very similar position as in *H. procera* Horvath. However, *H. taipehana* n. sp. is distinctly longer with longer head and longer antennal segments; the hind femora are also provided with unusually long hairs on hind margin. In *H. procera*, the antennal formula is as follows:—I, 15; II, 24; III, 65; IV, 45; the head formula-anteocular, 52 units; postocular, 25 units. In both species, the clypeus is short, fuscous, scarcely longer than wide with the apex broadly rounded. The female and long-winged form of *taipehana* are unknown. The wing pads are straplike, dark fuscous with whitish margin within, and extend on basal segment of abdomen.

HYDROMETRA BECKI, sp. new

Elongate, slender, moderately large, brown to brown-fuscous with head a little darker. Length, 12.50-13.20 mm.

Head: Dark fuscous or blackish, lighter basally. Length, 3.62

mm. Antecular part more than twice as long as postocular (108:45). Interocular grooves distinct, short, not extending beyond front and hind margins of the eyes, deeper and broader on ventral than on dorsal surface. Clypeus dark brown, shining, broadly impressed medially apically, widening apically, truncate at apex, there widest and more than twice as wide as median length. Antennae fuscous-brown, darker on apical half; proportion—I, 32; II, 60; III, 190; IV, 86. Rostrum brownish, not quite reaching middle of postocular part.

Pronotum: Brown, divided into two almost equal lobes in short-winged form, with the pruinose impressed median line extending from base to apex, a broad black-fuscous vitta on each side of line. Anterior lobe with an encircling row of small pits near front margin, the pits very small dorsally, larger beneath. Posterior lobe pitted, the pits rather small, more numerous near the median line and also on the sides. Median line pitted on hind lobe. Propleura with one row of pits near lower edge behind acetabula. Anterior acetabula with four pits (two on each side of cleft); middle acetabula also with two small pits on each side of cleft; hind acetabula with one small pit, sometimes not very distinct.

Legs: Long, brown-fuscous with all femora darkened apically; tip of fore femora extending a little in front of clypeus; tip of middle femora just attaining apex of clypeus; tip of hind femora surpassing the tip of last genital segment by nearly one-seventh of their length.

ABDOMEN: Length, 6.50 mm. Wing pads straplike, dark fuscous with veins darker, extending on the second abdominal segment or one-third of their length beyond hind acetabula. Hemelytra in macropterous individuals extending to penultimate. Connexiva margined dorsally with black-fuscous. Dorsal abdominal segments (save apical one) dark reddish brown. Venter yellowish brown, sparsely hairy, almost without hairs. In the long-winged form, front lobe of pronotum practically two-fifths as long as hind part.

Male: Last venter without male processes, a little shorter than penultimate segment, without conspicuous long hairs. Penultimate segment indistinctly ridged apically. First genital segment rather slender, obliquely truncate behind on the sides, subequal in length on median line to last venter; genital processes spinelike, dark, one on each side of venter located near edge of underside about one-third of length of segment from base, each process sharp, moderately long and tilted a little backwards and slightly outwards, terminating above in a conical, feebly tilted upward process.

Female: Last venter obliquely truncate on sides behind. Genital segment ending posteriorly in a conelike process, which is about one-half as long as rest of segment.

Type (male): and allotype (female), Guadalcanal, Solomon Islands, Dr. D. E. Beck, in my collection. Paratypes, specimens, in collection of Brigham Young University, Provo, Utah, and my collection.

This new species belongs to the group of the genus *Hydrometra* Lamarck which have the male genital processes placed on the first genital segment. It is most closely related to *H. illingworth* Hungerford and Evans, any may be separated from it by the nearly hairless venter and the position of the genital processes of the male, which are situated almost exactly one-third of the length of the segment from its base. Both species have the same number of pits on acetabula.



BUG ANNOYANCE IN THE SIERRA NEVADA FOOTHILLS OF CALIFORNIA

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INTRODUCTION

The writer has previously recorded annoyance to man by *Triatoma protracta* (Uhler), the western cone-nosed bug, in the west-facing Sierra Nevada foothills of California (Wood, 1942a, 1942b, 1950a, 1950b, 1951). These are brief reports of individuals having first hand contacts with these bugs but, with one exception, little scientific interest in the habits of the pests.

During the summer of 1950, the writer was able to study in some detail the behavior of *Triatoma protracta* and other arthropods under field conditions at the San Joaquin Experimental Range near O'Neal's, California. The writer's family of four occupied a wooden frame house of 1206 square feet floor space at approximately 1000 feet elevation topping a rolling hill.

OBSERVATIONS

Plate 35 shows the floor plan of this house with pertinent features indicated to show bug locations at time of capture. The solid symbols for male (♂) and female (♀) indicate bugs naturally infected with *Trypanosoma cruzi*, the causative agent of Chagas' disease or American trypanosomiasis. Each symbol represents one bug unless preceded by a numeral. The number encircled indicates the total catch for each room. Two concentrations of *Triatoma* are noticeable, one in the bedroom and one on Porch C. Both are explainable on the basis of easy access through natural bug crawl holes (X and Z) due to shifts in building structures. Both apertures were treated with 10% DDT dust about the middle of July when bugs were discovered using them. This probably explains the inability of certain individuals to feed as the male from outside of Porch C which showed a chemical stupor.

After examining the house, it was apparent that *Triatoma* could not exist in the attic because of almost daily lethal temperatures despite its occupancy at night by a Streater wood rat (*Neot-*

¹The writer is deeply appreciative of the many courtesies extended by Mr. Fred Douthitt, Superintendent, California Forest and Range Experiment Station, and Dr. Walter E. Howard and Dr. Loren E. Rosenberg of the Division of Zoology at Davis, University of California. Checking arthropod specimens was facilitated by access to the Los Angeles County Museum collections under the supervision of Dr. W. Dwight Pierce who identified the wasps.

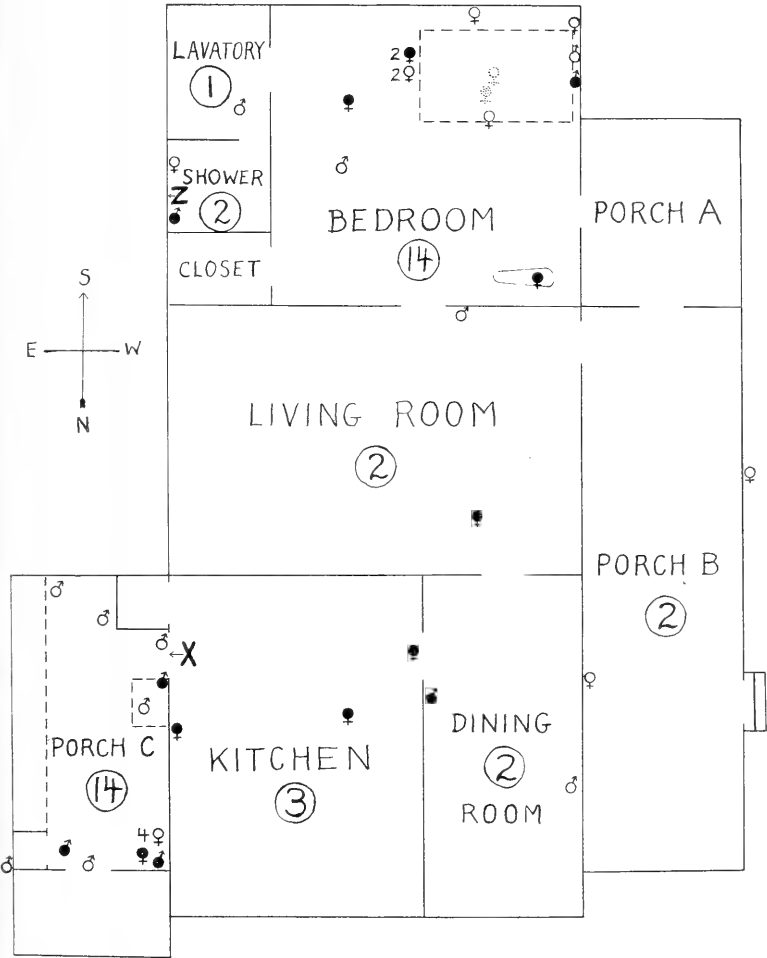


PLATE 35

oma fuscipes streatorii) and white footed mice (*Peromyscus*). The bugs gain access in the summer months to the living space from the sides, especially around doors, or the under surface of the house. There were many white footed mice (*Peromyscus maniculatus gambelii*) and several Pacific tree frogs (*Hyla regilla*) living under the house. The additional moisture under the house from watering seepage and shower floor leaks undoubtedly kept it much cooler with considerably higher humidities since general conditions above ground were very warm and dry, the average temperature means² and maxima for July and August being 79°F & 99°F and 75°F, & 97°F, respectively.

The use of ship-lap lumber for walls in some of the rooms created triangular openings to the attic and the subfloor area behind the 5 and $\frac{3}{4}$ inch baseboards which were sealed off at the floor with quarter round moulding. Since the *Triatoma* were coming chiefly from underneath the house, the triangular holes behind the baseboards were probed to see if any were open to the subfloor area, the floor being 1 to 2 feet above the ground surface.

Forty-four *Triatoma protracta* (19 males, 25 females) were collected between July 1st and August 28th, 1950 from this house. Fecal droppings of 43 were examined for blood parasites and 19 or 44.1% were naturally infected with *Trypanosoma cruzi* Chagas. The placement of 40 specimens is shown in Plate 1. The four additional specimens not specified as to location were from Porch C or the bedroom. Two male and one of two female bugs were naturally infected and all were collected on July 20th when a total of 5 *Triatoma* were taken. Most of these bugs were collected shortly after dark in the early evening or found hiding in the morning. The one female collected outside Porch B was heard by the writer while standing in front of the house shortly after dark. There was an audible, dull whirr as the bug flew to a rose leaf. The male on the outside corner of Porch C was found crawling out from a crack between the concrete porch and house wall at 4:30 P. M. It was probably affected by the DDT dust introduced under the kitchen door threshold (X, Plate 1).

Porch C north and west walls of ship-lap lumber afforded 36 triangular holes along the baseboard all of which were closed by the flooring. Therefore, *Triatoma* could not come up through these from under the house but could use them to hide in during the day. As shown in Plate 1, 14 specimens were collected in this location, of which 4 were infected. One male was found dead (probably heat killed) in a cardboard carton on the floor, one male was found in a paratrooper boot, one male was in the middle of the cement block near the kitchen door, one male was crawling

²The daily mean used here is an average of the means between each two hour difference during the day. Weather data supplied by Lisle R. Green.

on the floor, another male was found on the screen near the outside door, one male was in the northeast corner, 5 females and 1 male were on the guinea pig cardboard box and 2 males were found near the crack under the kitchen doorway threshold (X). The infected male and female from the guinea pig box were engorged but all others were collected before feeding. A concrete block had been placed near the kitchen door threshold for a washing machine and had settled faster than the porch leaving an opening under the threshold 1193 mm.³ long by 8 mm. at the south end and 11 mm. at the north end with the crack continuing 120 mm. along the edge of the concrete block with a minimum width of 10 mm. and then broadening out into the subfloor area under the house. This was the main portal of entry for *Triatoma* into this part of the house.

In the kitchen, 3 females were found on the floor at points designated. There were 38 triangular openings with 2 open along the west wall and 1 open along the east wall to the subfloor area.

The dining room served as sleeping quarters for the two children. Two male bugs were taken, one on the floor and the other on the moulding. There were 43 triangular openings along the baseboard with 1 open to the subfloor area along the west wall.

Porch B yielded one female on the wall and another outside the screening which extended around the porch. The outside porch door had a crack underneath it 2 to 9 mm. in depth from south end to north end. There were two water exits at the base of the 3 foot wooden siding partly blocked by screening under which were at least three apertures about 10 by 40 mm. between screen and flooring.

The living room yielded one female crawling on the rug and one male along the moulding. The room was well sealed.

The closet was well sealed except for an aperture 600 mm. long varying in width from 1 to 9 mm. along the floor next to the south wall.

The shower was well sealed above but the concrete base had sunken away from the sheet metal lining along the east wall leaving a crack 1168 mm. long varying in width from south to north from 1 to 9 mm. with a 10 mm. gap at the northeast corner of the floor where the male *Triatoma* was found. The female was walking along the wall to escape running water when collected.

The male bug from the lavatory was injured unknowingly having been stepped upon by a slipped foot. Half of its proboscis sheath was missing.

³One millimeter (mm.) is approximately 1/25 of an inch.

The bedroom yielded at least 14 specimens. Two male *Triatoma* fed upon the occupants and were found the following morning at the top end of the mattress and in the crack between mattress and box springs at the head of the bed. Four females were taken in or on black basketball shoes at the foot of the bed, one female was crushed underfoot on the rug, two females were taken on the edge of the rug under the center of the bed, another female was collected on the edge of the bed, one female trapped itself in a white enamel pan sitting on an ironing board, one male was found wandering across the floor and two females were collected on the moulding along the south and west wall. One of the latter females was heard at 3 A. M. making a clicking sound with leg and body movements while falling back on the floor during attempts to right itself from its back. The other was heard making the same sound at 4 A. M. but was not collected until 7 A. M.

Since the house was occupied for 58 days, less than 1 bug per day was found. Most specimens were intercepted in the early evening before retiring when the wall and floor surfaces were inspected with a flashlight. If the light was held close to the floor, the shadow cast facilitated spotting the bug. The largest number of *Triatoma* collected on any single day was July 20th and August 27th when 5 bugs were found on each of these days. Twenty-nine bugs were collected between July 15th and August 15th. Of the remaining 15, 6 were collected during the first part of July and 9 found during the latter part of August. Collecting was easier in this temporarily occupied house than in a home since there was less furniture, clothing, etc. in which the bugs could hide. Of the 44 bugs, only 2 were found actively moving about in the daytime, the female on the east wall of Porch B and the male on the outside corner of Porch C.

Of the 44 *Triatoma* taken, 40 were flat showing lack of recent engorgement although some were near the guinea pig on Porch C and in the bedroom for some time. Two of the 4 engorged insects fed on the guinea pig as noted above and 2 fed upon the sleeping occupants of the bedroom. As is noted in Plate 1, six specimens (1 male, 5 females) from the bedroom were infected with *Trypanosoma cruzi* including one male which fed on the sleeping occupants of the room. No reactions of any kind were noted. The female *Triatoma* from the enamel pan which had lost the tarsus on the left 1st leg and 3 females from the writer's basketball shoes were probably in the bedroom several hours. The female on the floor at the head of the bed was heard at 4 A. M. but not collected until 7 A. M. Thus, it would seem that even with high temperatures the hunger drive of *Triatoma protracta* is weak.

An additional 17 specimens were reported or collected from six other houses by Lisle Green, Fred Douthitt, Bob Naramore,

Kenneth Wagnon, Nate Cohen, and Russel Swanson. Twelve bugs were collected from 2 wood rat dens nearby. Of this total of 73 *Triatoma* for the headquarters area, 53 were examined of which 25 or 47.1% were positive for *Trypanosoma cruzi* Chagas. This is the highest incidence of infection ever reported for California where more than 15 bugs have been examined and indicates a potential reservoir of this parasite rimming the great central valley of California since four infected localities are now known for the Sierra Nevada foothills (Wood, 1950b).

Since *Triatoma protracta*, the western cone-nosed bug, is a carrier of the causative agent of Chagas' disease, such annoyance as indicated here is of public health interest. The contacts here show that there is a 10% chance of being fed upon by uninfected bugs and a 6% chance of serving as food for infected bugs in this house at this location. Therefore, even though the feeding drive appears weak, the bugs are few in numbers, and their efficiency in transmission of Chagas' disease is low, control measures should be instituted to rid man of this pest. The California Farmer for August 1950 recommends the use of a mixture of 2% wettable chlordane and 5% wettable DDT for killing these bugs.

Additional unbidden arthropod house guests included: the odorous house ant; the house fly; scorpions; wasps; a field cricket, *Gryllus assimilis* (Fabr.); a Jerusalem cricket, *Stenopelmatus*; several cockroaches, *Xestoblatta festæ* (Griffini); a praying mantid; a black widow spider and many screen penetrating small insects.

Thousands of odorous house ants, *Tapinoma sessile* (Say), were the most persistent and annoying house invader since they ate or carried away any unprotected foodstuff. Although they were most common in the kitchen, they were found in every room of the house. Their depredations caused considerable time loss in removal from invaded foodstuffs and some mental tension although the economic loss was slight. They invaded the gas refrigerator through worn door insulation and worked inside the box on especially hot days. Some relief was obtained by sprinkling 10% DDT dust about the floor supports of the refrigerator.

The house fly, *Musca domestica* Linn., was a minor pest of the kitchen area since no more than 5 were killed in any one day. There was good screening on the house and a general absence of suitable breeding sites near habitations.

Three scorpions, *Uroctonus mordax* Thorall, were taken in the following locations: one on the rug at the foot of the bed, one in the middle of the lavatory floor and another on Porch C floor near the kitchen door.

The wasps (Scoliidae, Cyphotinae) flew into the house at night

attracted by the indoor lights. One or two circled the light bulbs each night landing on any object nearby including occupants of the room.

A single female black widow spider, *Latrodectus mactans* Fabr., had built a web in the northeast corner of Porch B where it was in close contact with children and adults for several weeks until discovered and destroyed.

SUMMARY

The most annoying, house invading arthropods of the west-facing Sierra Nevada foothills included the western cone-nosed bug, *Triatoma protracta*, the odorous house ant, *Tapinoma sessile*, the house fly, *Musca domestica*, the scorpion, *Uroctonus mordax*, and the black widow spider, *Latrodectus mactans*.

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Dr. Mars Frederick Baumgardt

1890-1950

Dr. Mars Frederick Baumgardt passed from the scene of his constructive activities on this planet November 25, 1950.

Prior to the year 1936 he was a very active member of the Southern California Academy of Sciences, and served as its President from 1923 to 1925.

He was born in Portland, Oregon, March 7, 1890, the son of Bernard R. and Mary Louise (Steinhauer) Baumgardt.

Dr. Dinsmore Alter, in the *Griffith Observer* for April, 1951, aptly refers to Mars Baumgardt as Southern California's "best known amateur astronomer." In this, as in many other aspects, he succeeded his versatile and talented father.

For more than twenty years Mars Baumgardt was Director of the Clark Observatory in Los Angeles. This gave him the opportunity of popularizing the subject of astronomy, particularly with groups of children. With his wide variety of interests and talents he was able to reach and influence thousands of persons by means of his lectures and radio broadcasts. For years he lectured each Degree night to groups in the Scottish Rite library in Los Angeles.

Dr. Baumgardt was a past president of the Los Angeles Astronomical Society. He was very active in this organization for many years.

In 1939 he was appointed a member of the Board of Park Commissioners, and served continuously until the department was merged with the Recreation and Playgrounds Department.

He was a graduate of Polytechnic High School and of the Southern California College of Optometry and Ophthalmology, and received his degree of Doctor of Ophthalmic Science from Columbia University.

He was married in 1917 to Miss Melinda May Seay. His widow and two children, resident in Los Angeles, survive him.

Dr. Frank C. Clark

1869-1951

The death of Dr. Frank C. Clark in Redondo Beach, California, on February 5, 1951, removes another name from the list of past presidents of the Southern California Academy of Sciences.

Dr. Clark held this highest office in the Academy from 1920 to 1923. During that period he was a practicing Osteopathic Physician in Los Angeles, and in spite of many professional responsibilities, devoted a great deal of his spare time to the up-building of the Academy.

Frank C. Clark was born in Napa City, California, June 10, 1869. His early interests were along religious lines which led to his graduation from a Theological School in Irvington, California in 1887. Later, he developed an absorbing interest in natural history, and began to collect and study shells and fossils.

His interest in living things led to a fascinating hobby, that of carving miniature animals. Along with this, his native ability as a teacher, and his interest in children led to the formation of classes in carving and nature study. In spare time, throughout his life, he carried on this activity with young people.

Under the tutelage of Dr. Lloyd Holmes Miller, he was one of the first to excavate and study the fossil bones from the pits of Rancho la Brea.

He graduated from the Pacific College of Osteopathy in June of 1906, and for fourteen years thereafter taught the subject of comparative anatomy in that institution, and its successor.

Somewhere in the early 1920s Dr. Clark moved to Santa Monica, and shortly thereafter organized the Santa Monica Academy of Sciences, and served as its president for several years. In 1925 he organized the Santa Monica Forum.

Dr. Clark married in 1888. His widow, Dr. Annie Clark, and two brothers, Edward, and Robert, survive him.

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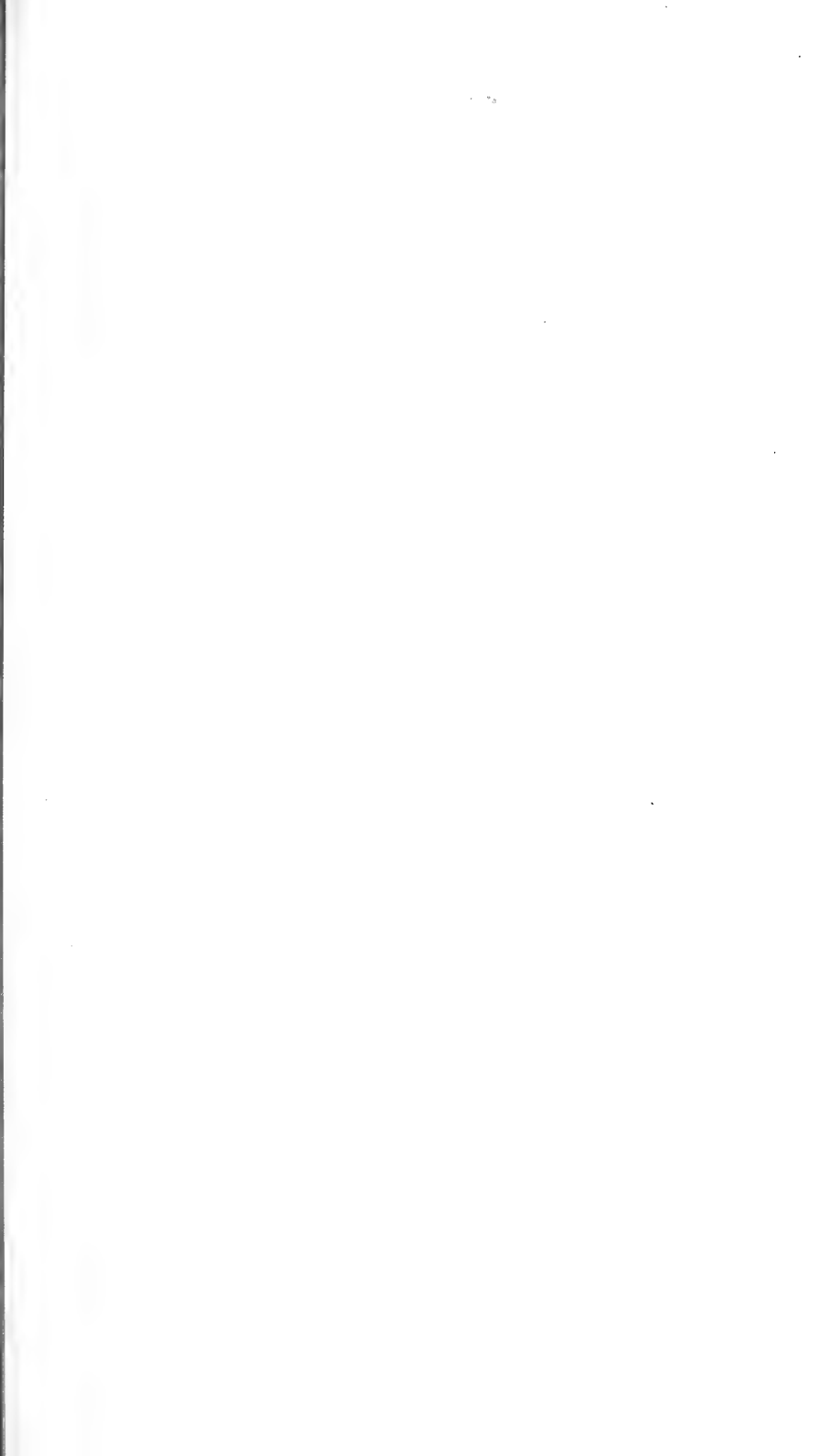
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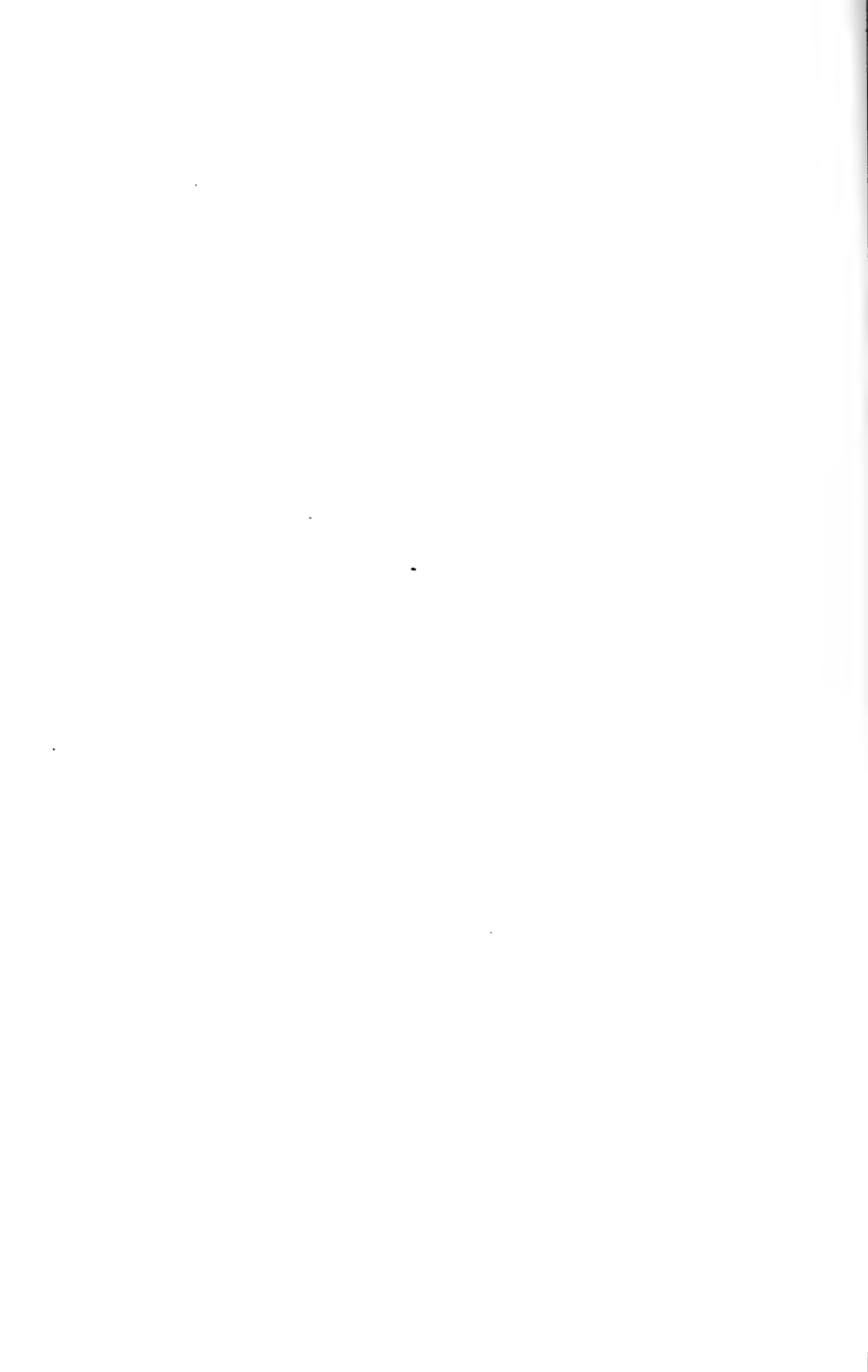
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THE OLFATORY SYSTEM OF TAILED AMPHIBIA

By WILLIAM A. HILTON

Department Zoology, Pomona College

The nasal capsules of salamanders have rather large chambers more or less protected by cartilage and bone. In the Proteidæ and Sirenidæ there is no bone dorsally, but in varying degrees the other families have capsules largely covered over and above with bone as well as cartilage. Usually a small area about the external openings are free from cartilage. In many, especially members of all families but Proteidæ, Sirenidæ and Amphiumidæ, two rather distinct regions are found in each olfactory chamber; the main portion or *cavum nasi* and a lateral, the *sinus lateralis nasi*. In the last the *ductus naso-lateralis* opens. In many the *sinus lateralis* is lined with ciliated epithelium.

Seydel '95, named a gland mesial to the *sinus lateralis* and under the *cavum nasi* as Jacobson's gland. Mihalkovics '98, considered this absent from salamanders, but concludes that the *sinus lateralis* which he calls *recessus maxillaris*, has a similar function of testing the external air current, that is, the structures are analogous, but not homologous with a true Jacobson's organ. Hinsberg, 1901, in the development of Triton came to the conclusion that a patch of sensory epithelium homologous with Jacobson's organ, arises medially and moves to a position lateral to the internal nares before this opening is completed. In this way the lateral position is a specialization of Urodela. Zuckermandl, 1910, agrees in general with the last, but because of the nerve supply does not believe in homology with higher vertebrates. Bruner, 1914, agrees with Seydel as to the location of Jacobson's organ and Herrick, 1914, from the nerve supply does believe that this organ is present in Urodela. Von Navratil, '26, does not agree with Seydel's homology of the *lateralis nasi*. Kurepina, '27, claims the existence of a primary oronasal groove between the nose and the mouth, therefore there can be no lateral shifting of Jacobson's organ.

In general then it is agreed that the *sinus lateralis* is the functional equivalent of Jacobson's organ, used for testing water currents.

The external nasal openings may differ in size as well as form. In adult Siren they are elongate slits and also to some degree in Necturus. In adult Amphiuma they may be a little more elongate, perhaps more oval than slit-like. In most of the others the openings are circular to oval, the appearance somewhat modified by their activity. In the Plethodontidæ the openings are from

circular to oval, always with a groove reaching from the nasal opening through the upper lip.

The nares differ greatly in size; not always correlated with the size of the animal. Some small species of *Plethodon*, *Batrachoseps* or *Desmognathus* may have openings not more than .2 mm. across, but in some species of the genus, *Thorius*, even smaller than these other plethodonts, the size of the nostrils is comparatively and actually very great. A head 1 mm. long might have a nostril .5 mm. across, about as large as the eye area in the same animal. In *Amphiuma*, large adult, the opening was 2 mm.

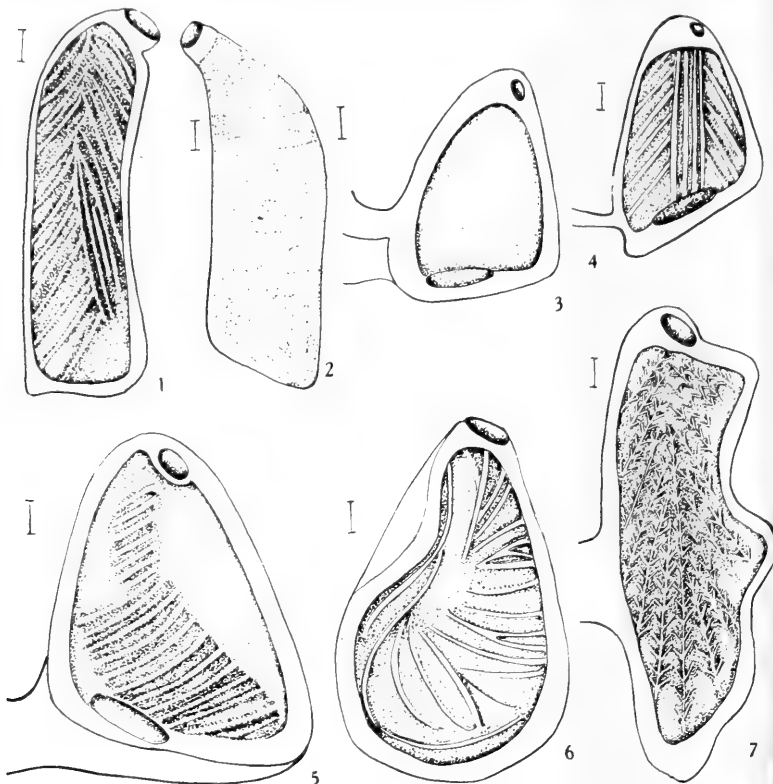


PLATE 36

Olfactory capsules of salamanders. Scale equals one mm. All but 2, views into the chamber after the removal of the dorsal wall, showing the surface of the ventral mucous membrane. Folds of the olfactory mucous membrane shown in all but 2 and 3.

1. *Necturus*. 2, Upper view of the olfactory capsule of *Necturus*, cartilage areas stippled. 3, *Salamandella*. 4, *Triturus torosus*. 5, *Cryptobranchus*. 6, *Siren*. 7, *Amphiuma*.

in its greatest diameter, but a large adult *Dicamptodon* where the nostril was circular or nearly so it was 2 mm. in diameter.

In all salamanders examined, but members of the *Proteidæ*, *Sirenidæ* and *Amphiumidæ*, where the nasal openings are circular to oval in outline, as far as examined in the living condition or suggested by preserved specimens of almost all species, the nostril seems to be closed largely from one side by the enlargement of an extensive lateral plug, due to the fact that the anterior rim is practically fixed in position, without movement when the opening is shut off from the exterior. This apparatus has been described in *Salamandra* by Bruner in 1896 and 1901. He describes three smooth muscles, one constrictor, two dilators. The *M. constrictor naris* bounds the caudal edge of the opening in little more than a semicircle, its ends being inserted on the anterior wall of the nasal fenestra on the cupullar cartilage portion of the nasal capsule. The *M. dilator naris* arises from the posterior border of the nasal fenestra, from the *cart. retro-narina* and passes forward to the caudal border of the nasal opening, being inserted into the constrictor muscle and the tissue binding it in the wall of the nasal opening. He also recognizes the *M. dilator accessorius* from the lateral border of the fenestra narina, from cartilage of the capsule and from the maxilla, to be inserted into the caudo-lateral margin of the nostril, deep in the fibers of the constrictor muscle, after taking an oblique course.

After the examination of this structure in a number of examples from all families, I can confirm these results in general, especially in these salamanders with circular or nearly circular openings and with the lateral nasal plug or operculum which closes the opening. This includes in general all families but *Proteidæ*, *Amphiumidæ* and *Sirenidæ* where the nostrils are more slit-like. In these last I did not find a lateral plug clearly indicated and the constrictor muscle was nearly if not entirely about the nasal opening with many fine fibers of a retractor function not limited to one side of the slit-like opening. Also in all those which I examined with a well-marked nasal plug I failed to convince myself that there was a distinct accessory oblique muscle.

The glands of the nasal region differ somewhat in various species. In almost all, in the mid-dorsal area between the olfactory sacs there is a large median gland which in some cases seems to have communication with the olfactory area. In some salamanders, especially members of the *Plethodontidæ* there are large glands either side of the nasal areas on top of the bone, with one or more ducts leading to the margin of the nostrils. Sometimes these extend back to the orbit and may have openings there but of that I could not be certain. Sometimes this gland or group of glands just under the skin and above the skull extend out laterally as part of the gland described or as more or less separate structure with its secretions also passed to the margin of the nasal opening. In addition to these there are glands in the nasal capsule in many

forms. They were seen in almost every species that I have examined. Francis '34 gives them for *Salamandra*, which might be considered typical, as follows:

The *glandula nasalis externa* situated above the sinus lateralis nasi within the fenestra narina very near the opening of the *ductus naso-lacimalis* into the nasal capsule.

The *glandula nasalis interna*, practically surrounding the cavum nasi within the nasal capsule. It keeps the olfactory epithelium moist.

According to Bruner '01, the muscles of the nostril are related to the *glandula nasalis externus* in such a way as to force the secretion out with the closing of the nasal opening.

It is possible that a poorer development of this last gland is correlated with the development of the external skull gland which supplies secretion to the nasal opening in *Plethodontidæ*. I have not seen this gland described before and so far have not seen it except in several but not all the genera, but especially in *Plethodon*, *Eurecea*, *Batrachoseps* and a few others of the family. As the word external is used in connection with another structure, the term *superficial* gland might be applied to it.

The inner surface of the nasal chamber has the mucous membrane sometimes smooth, in others quite complexly folded. Although there is much individual variation and some differences of appearance depending upon the method of preparation for examination the following is true:

The mucous membrane of the interior of *Necturus* is usually complexly folded with long high, diagonal folds. In *Cryptobranchus* nearly cross folds are found on the ventral surface. In *Siren* the folds are irregularly cross and longitudinal. In *Amphiuma* the folds quite well fill all the ventral surface of the mucous membrane, diagonal to longitudinally disposed with small lateral branches from the folds. In some *Salamandridæ* both longitudinal and diagonal folds may be found, but in all cases examined they were not prominent and in some the lining of the chamber was almost smooth. In the other specimens examined representing four families the mucous membrane was quite smooth.

In this description the lower surface has been described; the inner side of the upper side of the chamber is usually similar but not so marked as to ridges and folds.

The olfactory epithelium in many cases is very thick with many layers of nuclei. In certain especially prepared specimens long bipolar nerve cells were found scattered among the other long slender cells.

In general the development of the nasal capsule is as follows, following the condition in *Ambystoma* more closely than any other. This is based upon the study of dissections and serial sections of different stages and upon the work of Higgins 1920, who made wax plate reconstructions of various early stages.

The skeleton of the nasal area is a little later in the formation

of a cartilagenous capsule than the development of the otic capsules. The first indication of nasal pits is also well after the eyes are conspicuous with lens and cup. The olfactory pits develop rather slowly in stages before hatching and are at first mere shallow depressions in little flattened discs of thickened epithelium. The cavity slowly enlarges and extends out laterally and caudally. The penetration into the oral chamber comes about the time the cartilagenous trabeculae are in evidence; a little before or a little after depending upon the species. At first the ends of these trabeculae are not enlarged but before long they flatten out and form lateral parts, the *crista trabeculae*. Sometime later these ends of the trabeculae unite across the middle line to form a flat plate, the *planum basale*. At about this time isolated dorsal cartilages on each side, the *columna ethmoidalis* are formed as longitudinal rods dorsal to the basal plate. With later growth of these isolated rods they become fused with the trabeculae on each side in the *crista trabeculae* while the ethmoid columnnae are also united across the middle line in the narrow *pons ethmoidalis*. In a later stage, almost all parts become broader, the region of the bridge

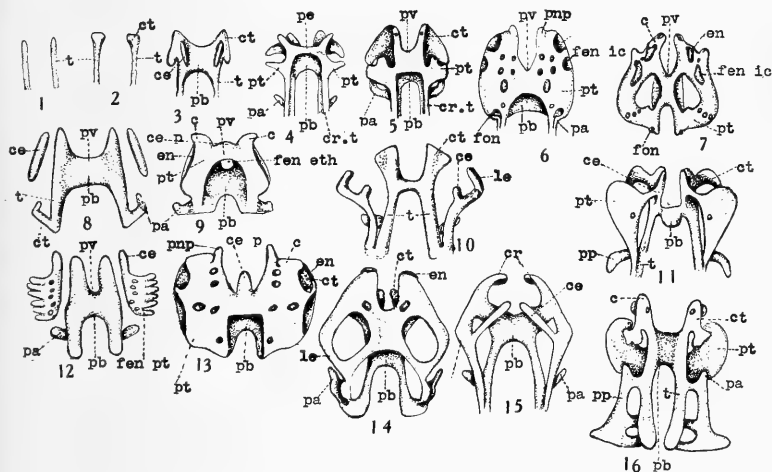


PLATE 37

Olfactory, cartilagenous skeleton of immature salamanders, largely after Higgins. All from above but 16; c, cupula; ce, columna ethmoidalis; cr t, crista trabeculae; ct, cornu trabeculae; ce p, cephalic processes; cr, circumnalar ring; en, external nares; fen pt, fenestrated process; fon, foramen orbito-nasalis; pa, processus antrorbitalis; pb, planum basale; pe, pons ethmoidalis; pt, planum tectale; pv, planum verticale; pp, ptergoid processes; t, trabecula; le, lamina externa.

1-7. Stages in the development of Ambystoma. 1, about 10 mm. 2, 11 mm. 3, 20 mm. 4, 25 mm. 6, 55 mm. 7, Young adult.

8 and 12, Necturus, 30 and 45 mm. 9 and 13, Salamandra, 38 mm. and young adult. 10, 15 and 14, Amphiuma. 11 and 16, Cryptobranchus, 5 weeks, and three months. 16 from below.

becomes the *platum verticale* with the *foramen nasalis internus* formed at the apex of the median part on each side near the median nasal incision. The *platum tectale* is a narrow lateral extension of the columna ethmoidalis and is now quite broad. There is also a lateral projection from the trabeculae, in front of the eyes, of the *process antrorbitalis* which at first is somewhat by itself, one on each side, but later joined in with the olfactory cartilage. At such a stage the olfactory capsules are nearly inclosed dorsally and ventrally; dorsally by the *platum verticale* and ventrally by the broader *platum basale*. Very soon the capsule is quite complete and the internasal space between the two capsules becomes more marked with the narrowing of the *platum verticale*. In an early stage a number of foramina and frontinellae are found, some remains of older ones, some new. The external nares are marked on each side and near the *fenestra infraconchalis*, at the caudal end on each side dorsally. In a later stage, much like the adult, large characteristic dorsal and ventral fontanelles are evident.

On the dorsal side in addition to the external nares are the *fenestra infraconchalis*, the *foramen orbito-nasalis* on each side.

In *Salamandra maculosa* a cephalic process develops from the *platum verticale* and also in early stages there is a *fenestra ethmoidalis*, neither of which are shown in *Ambystoma*, but the latter is found in *Triton*. The stages shown by Higgins for *Triturus viridescens*, one of which is an adult have less marked dorsal *fenestra* than I found in any adults of several species of this genus.

In *Cryptobranchus*, the nasal capsule is not formed until about two weeks from the time of hatching. At about five weeks, slender trabeculae unite at the middle line in a small *platum basale*, differing from other salamanders in that the dorsal surface is convex and bears a median swelling which may be the beginning of the *platum verticale*. Its cephalic edge is straight, its caudal region extended backward. The *platum tectale* on each side is broad, covering dorsal and lateral parts of the olfactory sac. The cornu trabeculae on each side instead of being broad is narrow. From each trabeculae there is a lateral backward extending process which Higgins considers the antroital, but it bends backwards without anterior projection to the pterygoquadrate. In a later stage the *platum basale* and *verticale* support the olfactory lobes with the capsules united by a broad *platum basale* without a median caudal lobe. The cornu trabeculae is now united to the anterior extension of the broad *platum tectale*. The bar of cartilage extending from the trabeculae backwards has extended back to unite with the anterior end of the pterygoquadrate bar which extends back to the otic region. This unique condition recognized by Higgins in *Cryptobranchus* is similar to that found by Wiedersheim in *Ranodon*, but according to Higgins is lost in adult *Cryptobranchus* and *Megalobatrachus*.

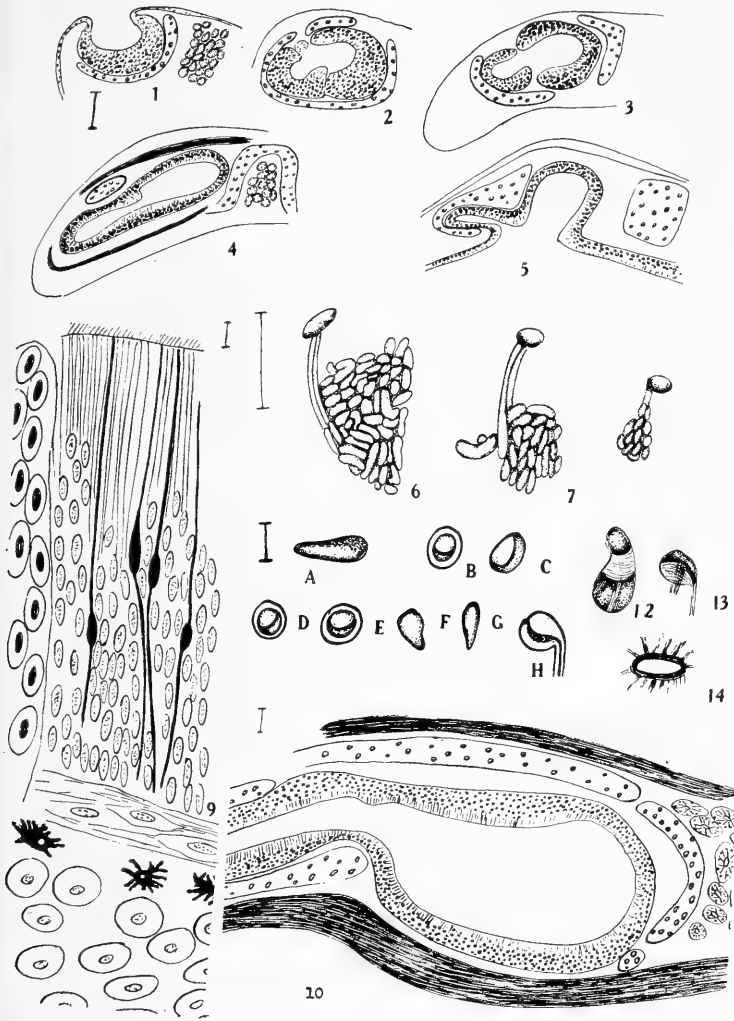


PLATE 38

Olfactory parts of salamanders. Scale equals 1 mm. in 6, 7, 8, 12, 13, 14 and A-H. Scale equals one-tenth mm. in 1-5. Scale equals one micron in 9 and one hundredth mm. in 10.

1-5. Various sections of the olfactory region on one side of *Desmognathus fuscus* of 30 mm. total length. Mucous membrane fine stippling; cartilage wider stippling; bone darker.

6. Superficial gland of *Plethodon glutinosus*, larger opening.

7. Same of *Eurecea guttolineata*.

8. Same of *Batrachoseps*.

9. Olfactory mucous membrane from *Necturus*, showing epithelium,

I found no indication of it in adult *Cryptobranchus* but I did see it in a larval *Cryptobranchus* which was probably older than the last stage described by Higgins, judged from the other parts of the larva.

In *Necturus* there is no true nasal skeleton up to about 25 mm. total length, but at about 20 mm. the trabeculae are almost united in one specimen which I have examined although in this there is little expansion of their ends. In a specimen of about 30 mm. the trabeculae are united across the middle line with the formation of p. verticale and p. basale which form the central plate between the trabeculae and isolated ethmoid columns are developed. In a larva of 45 mm. the ethmoid columns begin to form fenestrated plates, which here and in the adult are quite different from those of other families of Amphibia. The antrorbital processes are also evident.

In *Amphiuma* after the expansion of the cornu trabeculae there is a narrow connection across the middle line just below these expansions. From the trabeculae farther back lateral extensions run forward ending in two projections, the inner representing the ethmoid column, the outer the *lamina externa*.

A little later the narrow connection from side to side becomes broader to form the planum basale and the forward ends of the crista trabeculae or rather lateral and forward extensions from it form rings of cartilage, a special condition in *Amphiuma*. In a specimen of about 80 mm. total length, a circumnasal ring mentioned in the last stage is marked, the c. etmoidalis is very slender, the p. basale is broad, the p. antrorbitalis larger. At this early stage the large dorsal fontanelle is evident, and the ventral fontanelle is even more marked. In the adult there are a number of changes: the dorsal surface has two fontanelles dorsally, one quite small and the large one ventrally located; the p. basale has changed in form and more slender elements are fused in the capsule.

So far as they have been followed the olfactory skeletons of the Plethodontidae in young and older stages do not differ greatly from the general plan of development.

EXPLANATION OF PLATE 38

blood vessel at the side, connective tissue below and cartilage below this. Cells in dark olfactory nerve cells.

10. Cross section of olfactory region of a small Siren. This shows cartilage, bone, mucous membrane with inner glands at the right.

12. Diagram of olfactory muscles, after Bruner from *Salamandra*. Deep shading nasal cavity.

13. Nasal muscles of *Desmognathus*.

14. Diagram of the probable muscular arrangement in *Amphiuma*, *Siren* and *Necturus*. Nasal opening light.

A-H. Nasal openings of various forms, scale 1 mm. for all. A, *Siren*. B, *Ambystoma*. C, *Cryptobranchus*. D, *Hynobius*. E, *Triturus*. F, *Amphiuma*. G, *Necturus*. H, *Plethodon*, more enlarged than the rest.

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SYMPATRIC POPULATIONS OF *BATRACHOSEPS*
ATTENUATUS AND *BATRACHOSEPS*
PACIFICUS IN SOUTHERN
CALIFORNIA

By CHARLES H. LOWE, JR. and RICHARD G. ZWEIFEL*

The species vs. subspecies problem concerning the plethodontid salamanders *Batrachoseps attenuatus* and *B. pacificus* has not been adequately resolved due to lack of sufficient information concerning populations of these forms where they co-exist in southern California. During the past few years we have investigated several areas in southern California and Baja California with this problem in mind and recently have obtained additional evidence concerning the probable specific distinctness of these forms. In the present paper we are concerned with the problem of the specific or subspecific status of the salamanders and shall in addition discuss some of the several distinctive populations which occur within each entity.

B. attenuatus and *B. pacificus* are clearly morphologically distinct. *B. pacificus* attains a larger size and possesses proportional differences, the most conspicuous of which are longer limbs and larger head. They are equally distinct in coloration as well as in size. *B. attenuatus* has greater intensities of melanic pigmentation and greater development of guanophores on all surfaces. There is great variation in the amounts of guanophores present in each, but we have observed a constant and absolute difference in the distribution of these cells in the southern California populations which we have studied. Whereas both possess bluish or whitish guanophores distributed over the ventral surfaces as small (0.1 to 0.2 mm. in diameter), single cells, they are of much greater abundance in *B. attenuatus* in which form they are *equally abundant on the ventral surface of the tail* as on the other ventral surfaces. In *B. pacificus* they are less abundant in general and *absent or virtually absent from the mid-ventral surface of the tail*. As there are from approximately 100 to as many as 300 of these light cells on the ventral surface of the tail of *B. attenuatus*, this character is particularly useful in segregating the two forms when alive, inasmuch as it is dichotomous. However, this difference is by no means requisite to distinguish between the two entities once their total and marked differences are understood.

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Berry Campbell (1931) described an overlapping occurrence of *B. attenuatus* and *B. pacificus* in Los Angeles County, California, and concluded that they represented distinct species since they maintained their morphological distinctness where he found them side by side and under the same boards which afforded cover. Bishop (1943) and Hilton (1946) subsequently treated *B. pacificus* and its races as subspecies of *B. attenuatus*. Stebbins and Lowe (1949), however, followed Campbell in the suggestion that these forms are distinct species.

In a letter (January 5, 1950), Dr. Campbell kindly provided the authors with excellent directions for finding the spot where he first found the two salamanders together as reported in 1931. Using these instructions, on January 19, 1950, we were able to find both species living together at the same spot where they were first observed approximately 20 years before. Here the two forms maintain their characteristic morphological differences, no intermediates being found. This locality is in a residential district at Monterey Road and Palm Avenue in South Pasadena, Los Angeles County, California.

In March, 1949, we collected both *B. attenuatus* and *B. pacificus* within one mile of one another in similar habitats along the foothills of the Santa Ana Mountains in Orange County, California. In attempts to find both forms at the same locality and if possible under the same rocks or logs, we returned to this area in December, 1949, and in March, 1950, and succeeded on both occasions in finding individuals of both species under the same rock at 4.7 miles southeast of Irvine Park, Orange County, California. Plates 40 and 41 show the habitat of *B. pacificus* and *B. attenuatus* at this locality. Over 100 *B. attenuatus* and no *B. pacificus* have been collected under logs, chips of bark, and rocks on the ground under the canopy of the live oaks (*Quercus agrifolia*) lining and growing in the narrow drainageway. All 15 of the *B. pacificus* and six *B. attenuatus* were found under logs and rocks which were out in the open on the grass covered substratum without tree shade, including the rock shown in Plate 41. Here individuals of *B. pacificus* were found under rocks and logs near or in the mouths of holes made by the pocket gopher (*Thomomys bottæ*). One large adult escaped down a gopher hole when its covering rock was turned.

B. pacificus was taken only at the foot of the grass-covered hills, whereas the majority of *B. attenuatus* were found higher up and in the immediate vicinity of the oak-canopied drainageway. We found the adults of both *B. pacificus* and *B. attenuatus* under two of the rocks (approximate size 26"x32"x11") at the base of the hill and in the open a few feet from the shade of the oaks. In this area the two salamanders remain well segregated into two different effective environments and they overlap without evident gene exchange where the habitats adjoin. In the

effective environment of the smaller, more worm-like *B. attenuatus*, numerous earth-worm holes, as well as crevices in the soil about the roots of the trees, are available for the salamanders as dry season (summertime) retreats. In the effective environment of the larger and less numerous *B. pacificus*, holes made by the pocket gopher are available and are used for access to more suitable conditions when the ground surface is uninhabitable. In this connection, it may be pertinent to remark that in several years of field experience with these and other western salamanders, we have never found evidence that the salamanders themselves burrow in the soil, yet they must retreat beneath the surface of the ground or into other moisture sufficient places during the dry summer season.

At another nearby locality, 13.3 miles southeast of Irvine Park, we found both species a few yards from one another beneath and within fallen live oak logs under live oak woodland canopy varying from 50 percent to 75 percent. At this locality some *B. pacificus* show very slight, though more than usual resemblance to *B. attenuatus* in guanism of the dorsal surfaces, while *B. attenuatus* occurring sympatrically here with *B. pacificus* show no *B. pacificus* characters. This suggests the possibility of introgression of *B. attenuatus* genes into *B. pacificus* at this area of geographic contact. If introgression has occurred, it is suggested that it may have been only one way, i.e. from the smaller *B. attenuatus* into the larger *B. pacificus*.

An interesting interiorly located population of *Batrachoseps* was found in 1949 at five miles southeast of Redlands, San Bernardino County, by Mr. Kenneth S. Norris of Los Angeles. This population, while obviously resembling *B. pacificus*, shows some tendency in the direction of *B. attenuatus*. In March, 1950, an additional series of twelve specimens was collected from this locality and studied while alive; the data thus obtained are summarized in Table 1. In order to provide a better basis for the understanding of these data, a more detailed comparison of the pigmentation of an adult *B. pacificus* and an adult *B. attenuatus* from the area of sympatry in Orange County (4.7 mi. SE Irvine Park) is presented below. In view of the similarity of the Redlands population to *B. pacificus*, and because it is well isolated interiorly from the nearest *B. attenuatus* known to us, we are of the opinion that it represents a geographic variant of *B. pacificus* rather than the alternative of a hybrid population with introgression of *B. attenuatus* genes into *B. pacificus*. Neither interpretation, however, vitiates the concept that *B. pacificus* and *B. attenuatus* are distinct species.

Batrachoseps pacificus.—*Coloration*.—Ground color of upper surfaces light pinkish-brown from tip of snout to tip of tail, lighter on legs and feet. Melanophores form a continuous network (e. g. mid-dorsally) surrounding oval-shaped, gray colored

areas immediately surrounding gland orifices. All upper surfaces including legs and feet with sparse scattering of small (0.1-0.2 mm. diameter) bluish or grayish-white guanophores; approximately 90 on head and neck, 150 on body and 50 on tail. In addition to these larger whitish guanophores there is a second and more abundant type (which may not be true guanophores) which is generally smaller and colored either sparkling gold, yellow, or orange. These do not form a conspicuous dorsal band (as in *attenuatus*) but are occasionally clumped to form small reddish or brown-orange patches which are most conspicuous on the tail. Ground color of *lower surfaces* lighter, being faint pinkish-brown. Melanophores tend to be separated as individual cells rather than as a continuous network as on upper surfaces which are darker. Ventrally, guanophores are pale in color and less abundant; 7 in throat area, 21 on abdomen, none on tail. Dorsolateral and lateral body areas have greatest abundance of guanophores. *Iris* with good scattering of sparkling orange and yellow guanophores in upper half and with 3 or 4 small flecks in lower half.

Batrachoseps attenuatus.—*Coloration*.—Ground color of *upper surfaces* black to blackish-brown; intensity of melanic pigmentation most reduced on legs and feet. Melanophores (e. g. mid-dorsally) do not form an apparent network encompassing grayish oval-shaped areas, but appear solid black both macroscopically and microscopically under low powers of magnification. Higher powers of magnification reveal an essentially network arrangement of melanophores surrounding lighter areas at the orifices of the glands. Small (0.1-0.2 mm. diameter) individual bluish guanophores are distributed more or less evenly over the dorsal surfaces; approximately 55 on head and neck, 90 on body and 40 on tail. They are more deeply blue colored and somewhat less abundant on upper surfaces than in *B. pacificus*. The second type of sparkling gold and yellow colored guanophores are vastly more abundant than in *B. pacificus* and form a dorsal band or suffusion from tip of snout to tip of tail. They occur in reduced abundance on lateral surfaces of body where they are separated from the main dorsal band by irregular dorso-lateral stripes of dark ground color. The ground color of the *lower surfaces* is lighter, being blackish to blackish-brown. Melanophores form a dense network not unlike the dorsal surface of *B. pacificus*. Small bluish guanophores present are darker blue (possibly because of darker underlying ground color) and much more abundant than in *B. pacificus*; approximately 360 on head and neck, 700 on abdomen and 300 on tail. *Iris* with a good scattering of sparkling light yellow guanophores in upper half and 3 or 4 small flecks in lower half.

In addition to the sympatric populations now known from both Los Angeles and Orange Counties, Campbell (op. cit.) has reported that both *B. attenuatus* and *B. pacificus* occur together on

Santa Cruz Island, Santa Barbara County, California (Plate 39). Mr. John Hendrickson of Berkeley, California, has recently confirmed the presence of both species on this island and has kindly allowed us to mention this discovery. *B. attenuatus* is known from no other channel island. Insular populations of *B. pacificus* are known on Santa Catalina, Santa Cruz, San Miguel and Anacapa Islands off the coast of southern California. Both Bishop (*op. cit.*) and Hilton (*op. cit.*) have included Santa Barbara Island within the range of *B. pacificus*, but this is unlikely since they cite no specimens and none was collected there during the course of the Los Angeles County Museum Channel Islands Biological Survey. The "northern group" of islands (not including Santa Barbara Island) is frequently referred to as the "Santa Barbara Islands." This situation is a source of confusion contributing to the probably erroneous reference of *Batrachoseps* to the meager fauna of Santa Barbara Island, which so far as is known includes only one reptile (*Xantusia riversiana*) and no amphibians.

As now known, the mainland distribution of *B. Pacificus* is within the drainage systems of the Los Angeles, San Gabriel and Santa Ana Rivers and, roughly, is the southern California coastal plain. Locality records range from near the ocean (Long Beach) north to the edge of the San Gabriel Mountains and northeast (interiorly) to the variant population reported herein at five miles southeast of Redlands. In contradistinction, *Batrachoseps attenuatus* in southern California is found in the foothills and mountain canyons (Upper Sonoran Life-zone), usually associated with live oaks and/or chaparral. *B. pacificus*, inhabiting more level areas which are lower zonally, overlaps *B. attenuatus* in areas where the transition from mountains to plain is made less abrupt by the presence of a belt of low foothills. At other places, as along the south edge of the San Gabriel Mountains, the line of demarkation may be quite sharp.

To summarize, we have found *B. attenuatus* and *B. pacificus* in the same habitats in Orange County, California, and have confirmed Campbell's report that they co-exist in Los Angeles County, California. In both counties, embracing nearly the entire latitudinal mainland distribution of the restricted species *B. pacificus*, individuals of each entity may be found under the same cover such as rocks and boards. Both species maintain their distinctive identities although breeding populations occur side by side. Thus it appears, so far as our present information goes, that *B. attenuatus* and *B. pacificus* represent two closely related but distinct species.

A new geographic variant of *B. pacificus*, significantly distinct from the known remainder of this highly geographically restricted species is reported from five miles southeast of Redlands, San Bernardino County, California. This population shows

a degree of intermediacy in characters of *B. pacificus* and *B. attenuatus*. The possibility that it represents a former introgression of genes of *B. attenuatus* into *B. pacificus* is discussed. Regardless of whether this population (or others) represents introgression or whether it represents geographic variation within *B. pacificus* as is suggested, it does not vitiate the concept that two distinct entities are involved, each representing an approximately, if not completely, closed genetic system.



PLATE 39



PLATE 40



PLATE 41

EXPLANATION OF PLATES ON PAGE 133

Plate 39. Distribution of *Batrachoseps* in southern California. All records for *B. pacificus* represent specimens examined by the authors. *B. attenuatus* records include literature records.

Plate 40. Live-oak woodland-grassland habitat of *Batrachoseps attenuatus* and *B. pacificus* 4.7 mi. SE Irvine Park, Orange Co., California. *B. pacificus* was found only in the uncanopied grassy area in the foreground. *B. attenuatus* occurred abundantly in the drainageways shaded by live oaks (*Quercus agrifolia*) and sparingly in the open, grassy area.

Plate 41. Close-up view of the large rock (26"x32"x11"), shown in foreground of Plate 40, under which individuals of both *B. pacificus* and *B. attenuatus* were found.

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Stebbins, R. C. and C. H. Lowe, Jr.

1949. The systematic status of *Plethopsis* with a discussion of speciation in the genus *Batrachoseps*. Copeia, No. 2: 116-129.

TABLE 1: COMPARISON OF POPULATIONS DISCUSSED IN THE TEXT

	SNOUT-VENT LENGTH IN MILLIMETERS	SUB-CAUDAL GUANOPHORES	DORSAL GUANOPIHORE PATTERN	TOTAL MELANIN
<i>B. attenuatus</i> (Los Angeles and Orange counties)	36.04 \pm 0.13 (32.5-39.0) N = 22	Abundant	"Attenuatus" type (see text)	Abundant
<i>B. pacificus</i> (5 mi. SE Redlands, San Bernardino County)	37.38 \pm 0.28 (34.0-42.0) N = 9	Present only on tip of tail	6 intermediate, 6 as in <i>pacificus</i> N = 12	5 intermediate 7 as in <i>pacificus</i> N = 12
<i>B. pacificus</i> (Los Angeles and Orange counties)	44.40 \pm 0.34 (40.0-52.0) N = 13	Absent from mid-subcaudal surface	"Pacifcus" type (see text)	Less abundant

THE ISOPODAN GENUS *IAIS* (CRUSTACEA)*

By R. J. MENZIES and J. LAURENS BARNARD

Research Fellows
Allan Hancock Foundation

INTRODUCTION

The genus *Iais* contains very small asellote isopods which are found in association with isopods of the family Sphæromidæ. None of the species which we have seen was collected from outside of this association and we believe that reports of *Iais* alone, without a sphæromid, are possibly in error (Chilton, 1892, pp. 266-267). We have had occasion to observe *Iais californica* (Richardson) on *Spharoma pentodon* Richardson, where they were found on the dorsum, ventral surface, and between the leaf-like pleopods. A few were found on the sides of the burrows occupied by the host.

Initially this project had as its purpose only the redescription of *Iais californica* (Richardson). This, Richardson had placed in the genus *Janiropsis*. Since Vanhöffen (1914, pp. 530-531), Monod (1926, pp. 13-14), and Nordenstam (1933, p. 179) were of the opinion that only one species existed in the world, e.g., *Iais pubescens* (Dana), it became necessary for us to procure specimens of *I. pubescens* with which to compare the Californian species. Specimens of *I. pubescens*, including some samples which had been examined by Bovallius, the author of the genus *Iais*, were sent to us by Dr. Karl Lang of the Swedish State Museum in Stockholm, and we offer our gratitude to him and the Swedish State Museum for the privilege they so generously extended. The work was carried out under the auspices of the Allan Hancock Foundation in the laboratory of Dr. John S. Garth to whom we extend our thanks for the use of facilities and equipment.

In the paper we redescribe *Iais pubescens* (Dana), consider *I. californica* (Richardson) a valid species, and present the description of a new species from the Philippine Islands and Singapore.

GENERIC REMARKS

When Bovallius (1887, p. 50) described the genus *Iais* he did not designate a type species. He did mention two species: the first was his own, *I. hargerii*, and this he described in detail; the second, *I. pubescens* (Dana), he assigned to the genus with some doubt because of differences between Dana's description and his

*Contribution No. 90 from The Allan Hancock Foundation, The University of Southern California, Los Angeles 7, California.

specimens, and because some omissions made by Dana made him uncertain whether it belonged to his new genus. Bovallius did not see Dana's material collected at Nassau Bay, Tierra del Fuego, from *Sphæroma*, and which as far as we know has been destroyed. Bovallius' species was collected from the Strait of Magellan, but no mention was made as to whether it was taken from a sphæromid. From certain of Dana's figures (not his description which is inaccurate in a few important details) and from Bovallius' description it appears that both were dealing with the same species. This supposition was made very early by Stebbing (1900, pp. 548-549) who made exceptional allowances for errors in Dana's figures and descriptions which we did not feel worth accepting until we had examined specimens from the type localities. We have seen specimens from both localities (from sphæromids) and as far as we can tell only one species is represented. The type of *I. hargerii* is apparently lost for good because the vial which should have contained it had a species of asellote so different from *I. hargerii* (*fide* Bovallius) that Dr. Lang suggested (in letter) that an exchange had probably occurred at some time and a specimen belonging to a different genus substituted. Certainly, there is no way to clear up the confusion at this late date.

Only two important errors appear in the original description of the genus. First, a small although evident rostrum does exist and second, the dactyls of the peræopoda are not all triunguiculate. The dactyls of the first pair are biunguiculate, having the inferior claw bifid, exactly as figured by Dana. As in several genera of the Asellota, the dactyls of the other peræopoda are triunguiculate.

GENUS IAIS BOVALLIUS, 1887

TYPE SPECIES.—IAIS HARGERII Bovallius, 1887=JÆRA PUBESCENS Dana, 1852.

Diagnosis.—(modified after Bovallius.) Eyes present, each consisting of two facets. First antenna with six articles. Second antenna without a scale. Epimeral plates visible in dorsal view on all peræonal somites. Lateral margins of peræonal somites not deeply incised, borders setiferous. Apex of male first pleopod not widely expanded laterally. Third pleopod without plumose setæ on endopod. Dactyls of first peræopods with two claws; those of others with three claws. First two articles of maxillipedal palp as wide as endite; apical three articles much narrower than endite. Mandible with a triarticulate palp and with an evident, elongate, apically blunt molar process.

Composition.—Nierstrasz (1941, pp. 287-288) appears to be the most recent writer to treat this genus. He records two species, *I. pubescens* (Dana) including the var. *longistylis* Chilton (Chil-

ton, 1912, p. 131), and *I. hargerii* Bovallius as belonging to the genus and remarks, "Beide Formen sind wahrscheinlich identisch, und weil keine anderen Arten von *Iais* bekannt sind, hat dann die einzige Art eine südlicheircumpoläre universelle Verbreitung." This remark, which clearly is in accord with prior opinion concerning the distribution, we feel is partly incorrect. It is conceivable that *I. pubescens* (Dana) is a circumpolar antarctic species but from the evidence we have seen it is improbable that the species is universally distributed. Most of the references to the species *I. pubescens* are notes on occurrence. Usually no additional figures or description are given. This is probably because of the belief that only one species existed and hence nothing further was needed. We prefer to place mere references to the species from localities far removed from the type locality in a list of *species inquirendæ*. The collection and study of material from the localities referred to might assist in the correct assignment of the disputed synonyms to their proper species.

A KEY TO THE SPECIES OF THE GENUS IAIS

1. Inferior (accessory) claw of dactyl of first peræopod bifid.
.....*pubescens* (Dana)
1. Inferior claw of dactyl of first peræopod simple, not bifid...2.
2. Maxilliped with three coupling hooks.....
.....*californica* (Richardson).
2. Maxilliped with two coupling hooks.....
.....*singaporensis* new species.

IAIS PUBESCENS (Dana)

Plates 42-43

SYNONYMS.—*Jæra pubescens* Dana, 1852, p. 744, atlas, pl. 49, figs. 9a-d.—Beddard, 1886, pp. 19-20, pl. II, figs. 6-10.

Iais Hargerii Bovallius, 1886, pp. 50-51.

Iais pubescens (Dana).—Bovallius, 1886, pp. 51-52.—Stebbing, 1900, pp. 549-551.—Chilton, 1909, pp. 649-650.—Vanhöffen, 1914, pp. 530-531.—Stephensen, 1927, p. 356.—Monod, 1931a, p. 13.—Nordenstam, 1933, pp. 177-179, fig. 41.—Nierstrasz, 1941, pp. 287-288.

Diagnosis.—First antenna about one seventh as long as body and one fifth as long as second antenna. Second antenna more than two thirds as long as body; flagellum with twenty-six ar-

ticles. Maxilliped with two coupling hooks. Peraeal somite 4 overlaps the borders of somites 3 and 5. Peraeal setae moderately developed. Inferior claw of dactyl of peraeopods one to seven bifid. Lateral subapical processes of sympod of male first pleopods diverging, subacute, each with a laterally located notch; medial processes triangulate, provided with four marginal setae. Pleotelson longer than wide, posterior border evenly rounded.

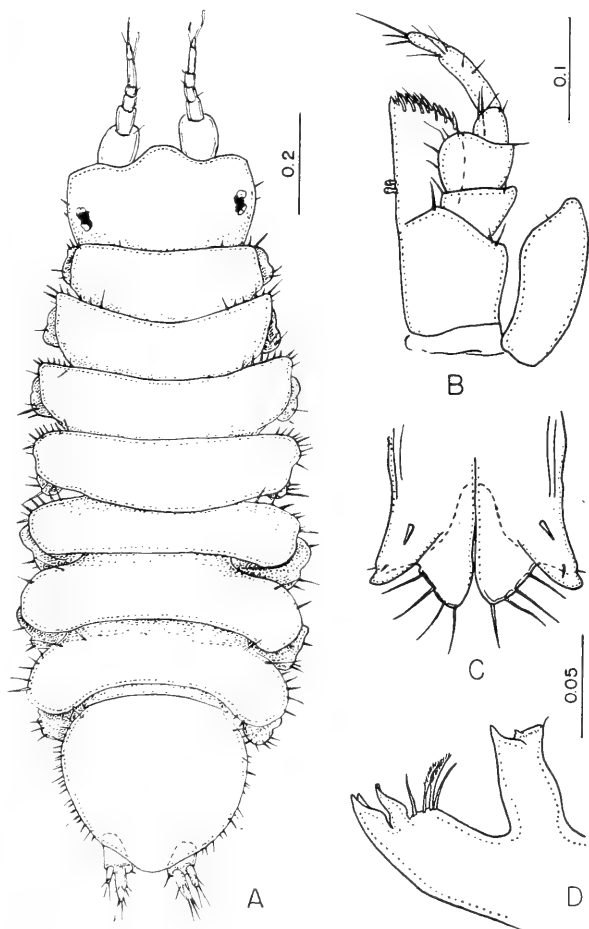


PLATE 42

Iais pubescens (Dana). a, toto, adult female. b, maxilliped. c, apex of male first pleopods. d, apical parts of left mandible. Figures with similar magnification (indicated by mm. scale); a; b; c, d.

Uropod one third as long as pleotelson, endopod as long as peduncle, exopod shorter than endopod. Operculum of female pyriform, with a truncated process on posterior edge.

Type locality.—Nassau Bay, Tierra del Fuego (Dana, 1852, p. 744).

Material examined.—We have examined the material mentioned by Nordenstam (1933, p. 179) from the Falkland Islands,

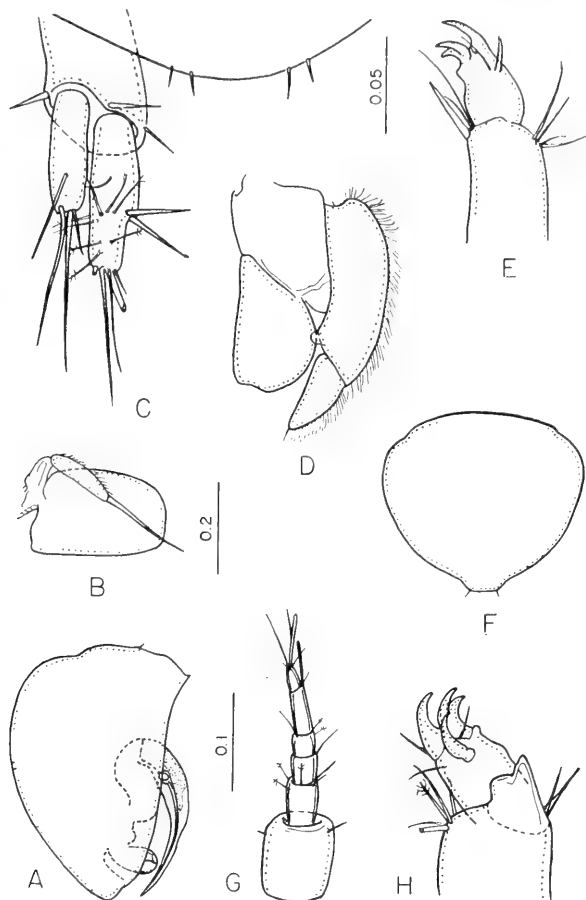


PLATE 43

Iais pubescens (Dana). *a*, male second pleopod. *b*, male fourth pleopod. *c*, uropod and apex of telson. *d*, male third pleopod. *e*, dactyl of first peraeopod, female. *f*, operculum of female. *g*, first antenna. *h*, dactyl of seventh peraeopod, female. Figures with similar magnification: *a*, *d*, *g*; *b*, *f*; *c*, *e*, *h*.

Magellan Straits, and Tierra del Fuego. This material was collected by the "Eugenie" Expedition, the Swedish Expedition to Tierra del Fuego, and the Swedish Antarctic Expedition.

Remarks.—For reasons given earlier we believe *I. hargeri* Bovallius to equal *I. pubescens* (Dana). Stebbing (1900, p. 549) was also of this opinion but it seems he was too liberal in supplying *I. pubescens* with synonyms. We prefer to place some of his synonyms in a *species inquirendæ* list. One species, *Jæra antarctica* Pfeffer (1887, pp. 134-136, pl. 7), belongs to *Neojæra* (Nordenstam, 1933, pp. 187-189) and not to *Iais*.

Distribution.—*Iais pubescens* (Dana) appears to be an Antarctic circumpolar species, having been taken at the following locations: Falkland Isls., Tierra del Fuego and vicinity (Nordenstam, 1933). Kerguelen (Beddard, 1886; Vanhöffen, 1914), Auckland and Campbell Isls. (Chilton, 1909; Monod, 1931a), and Tasmania (Stephensen, 1927).

IAIS CALIFORNICA (Richardson)

Plates 44-45

SYNONYMS.—*JANIOPSIS CALIFORNICA* Richardson, 1904a, pp. 223-224.—1904b, pp. 666-667.—1905, p. 455, figs. 507-508.

Diagnosis.—First antenna about one sixth the length of the body and nearly three tenths as long as the second antenna. Second antenna about six tenths the length of the body; flagellum with twenty four articles. Maxilliped with three coupling hooks. Peræonal somite 4 overlapping the border of somite 3 but overlapped by the border of the fifth somite; peræonal setæ moderately developed. Inferior claw of dactyl of peræopods one to seven simple, not bifid. Lateral subapical processes of sympod of male first pleopod not diverging laterally, lateral margins smooth; medial processes subtriangulate, provided with 5 marginal setæ. Pleotelson wider than long, posterior border medially produced into a lobe. Uropod slightly more than one half as long as pleotelson; rami subequal in length, twice as long as peduncle. Operculum of female wide, with a small, rounded, medial process on distal margin.

Types.—These have been lost, according to Dr. Fenner A. Chase, Jr., Curator of Marine Invertebrates at the United States National Museum, Washington, D. C.

Type locality.—Sausalito, California, collected by Dr. Ritter and party (Richardson, 1905, p. 455).

Material examined.—Hamlet, Tomales Bay, Marin County, California, August 18, 1948, coll. R. J. Menzies, in excess of 50 specimens from *Spharoma pentodon* Richardson and the burrows of *Spharoma* in submerged wood.

Distribution.—Tomales Bay to Sausalito, San Francisco Bay, Marin County, California.

Remarks.—Assuming that our material and hers are conspecific, Richardson's description of the species is incorrect in several details. Some of these are corrected in the above diagnosis but a few additional remarks are needed. The eyes are compound and not simple; the margins of the pleotelson are not smooth, but are covered with numerous setæ; all pereopods except the first have triunguiculate dactyls.

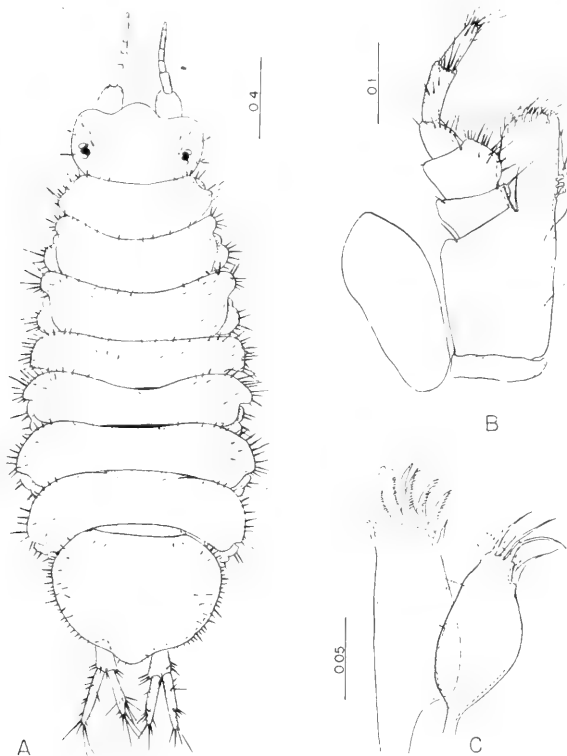


PLATE 44

Iais californica (Richardson). *a*, toto, female. *b*, maxilliped. *c*, first maxilla. Magnification as indicated by mm. scale.

This species differs from the others belonging to the genus in having very long uropods and in having three coupling hooks on each maxilliped.

One adult male was 2.7 mm. long and 1.0 mm. in greatest width. Richardson gave no measurements.

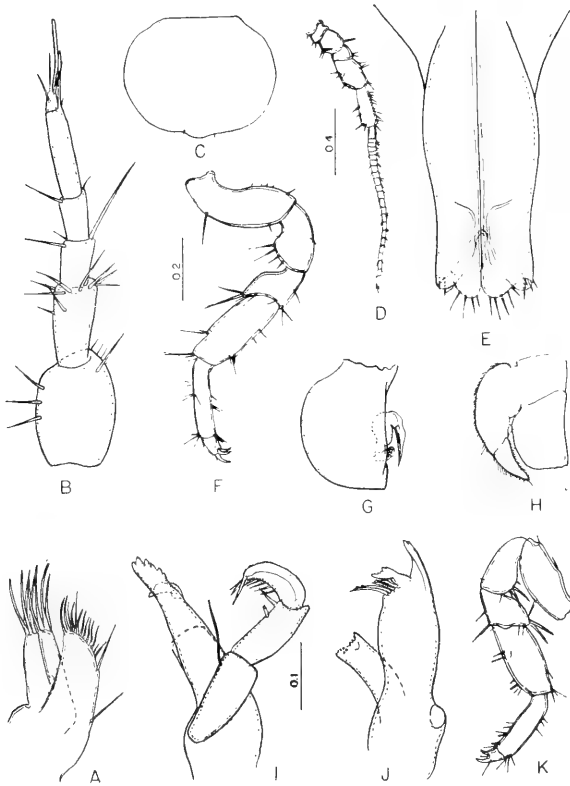


PLATE 45

Iais californica (Richardson). *a*, second maxilla. *b*, first antenna. *c*, female operculum. *d*, second antenna. *e*, male first pleopods. *f*, seventh peraeopod. *g*, male second pleopod. *h*, male third pleopod. *i*, left mandible. *k*, first peraeopod. Figures with similar magnification: *a*, *b*, *e*, *i*, *j*; *c*, *f*, *g*, *h*, *k*; *d*.

IAIS SINGAPORENSIS, new species

Plates 46-50

SYNONYMS.—None.

Diagnosis.—First antenna short, about one fifth the length of the body and one third as long as the second antenna. Second antenna slightly less than two thirds as long as body; flagellum with twenty articles. Maxilliped with two coupling hooks. Peraeonal somite 4 overlaps the border of somite 3, but is overlapped on its posterior border by the fifth somite. Inferior claw of dactyls of pereopods one to seven simple, not bifid. Lateral subapical processes of sympod of male first pleopods not diverging, medial processes with rounded, slightly acute, apices; each with five to eight marginal setae. Pleotelson slightly wider than long, apical process rounded, very noticeable. Uropod one half to one third as long as pleotelson, rami subequal in length, longer than peduncle. Female operculum wide, with a pronounced apical lobe.

Types.—Holotype male, length 1.7 mm., width 0.7 mm. Allotype, ovigerous, length 2.3 mm., width 0.85 mm. Thirty paratypes. Six paratypes donated to the Swedish State Museum and six donated to the Allan Hancock Foundation. The other types have been returned to the Raffles Museum, Singapore.

Type locality.—Seletar and Ponggel, Singapore Island, May-June, 1950, types, on *Spharoma* sp., collected by the Raffles Museum and lent to the writers by Dr. Tweedie, carcinologist.

Material examined.—(exclusive of types). Dungun, Trengganu, east coast of Malaya, December, 1950, 3 males, 12 females, on *Spharoma* sp., collected by the Department of Forestry, Raffles Museum collection.

Sungei, Patani, Kedah, Malaya, February, 1951, 2 males, 21 females, on *Spharoma* sp., collected by the Department of Forestry, Raffles Museum collection.

Dagatdagatan Saltwater Experiment Station, near Manila, Luzon, Philippine Islands, December 12, 1949, 96 specimens, collector Mr. Manuel Tiglaio, Philippine Bureau of Fisheries.

Remarks.—The specimens from Singapore (Plates 46-47) and those from the Philippine Isls. (Plates 48-50), as the figures indicate, are very different in some respects. Specimens from Dungun and Sungei, Malaya, which we received from Dr. Tweedie, possessed characteristics intermediate between the two. This possibly indicates that a "rassenkreis" involving two or possibly more subspecies is represented. Without further material we do not feel it advisable to establish subspecies. We are, however, reasonably certain that only one species is involved. This species resembles *I. californica* (Richardson) in having long uropods and in having a simple inferior claw on the dactyls of the pereopods. It differs conspicuously from *I. californica* in having only two coupling hooks on each maxilliped.

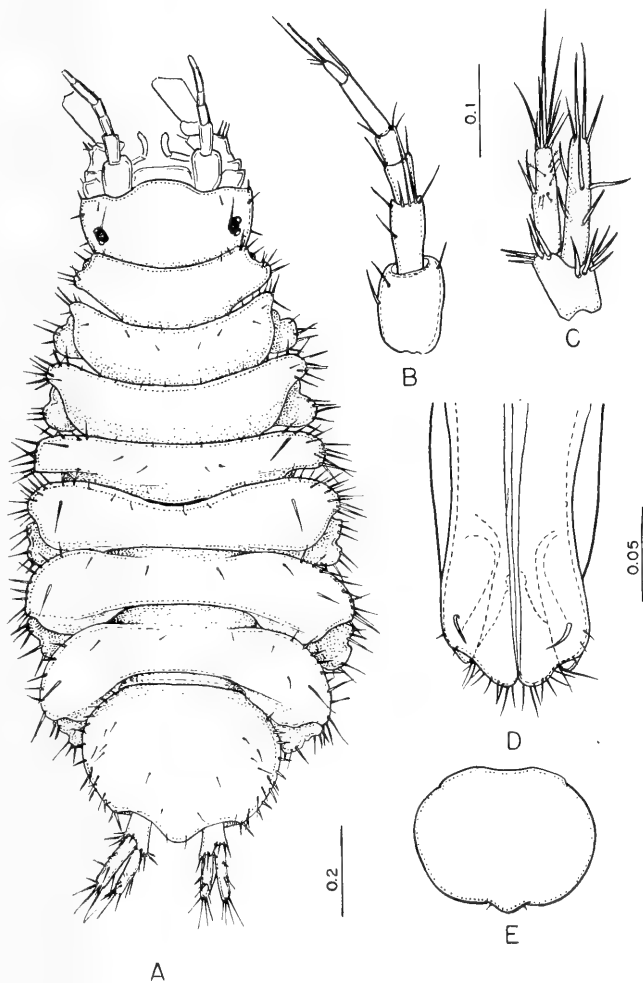


PLATE 46

Iais singaporensis Menzies and Barnard, n. sp., paratype. *a*, toto, female. *b*, first antenna. *c*, uropod. *d*, apex of first male pleopods. *e*, operculum of female. Figures with similar magnification: *a*, *e*; *b*, *c*; *d*. (Singapore).

SPECIES INQUIRENDÆ

1. *Iara novæ-zealandiæ* Chilton, 1883, p. 189 (Lyttelton Harbour, New Zealand).
2. *Iais neo-zealanica* (Chilton), Thomson, 1889, p. 265 (Auckland Harbour, New Zealand).

3. *Iais pubescens* (Dana), Thomson, 1893, p. 59 (New Zealand).
4. *Iais pubescens* (Dana) var. *longistylis* Chilton, 1912, p. 131
(Malborough Sound and Hawkes Bay, New Zealand, also from
Sydney Harbour).

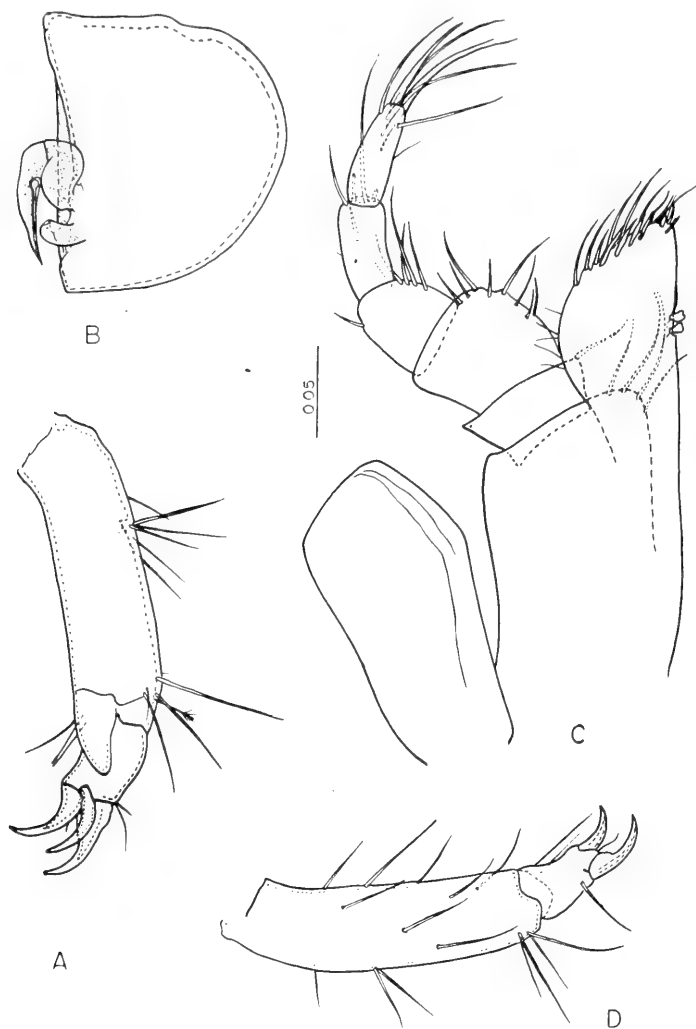


PLATE 47

Iais singaporensis Menzies and Barnard, n. sp., paratype. *a*, dactyl and propod of seventh peraeopod. *b*, male second pleopod. *c*, maxilliped. *d*, dactyl and propod of first peraeopod. All figures with similar magnification. (Singapore).

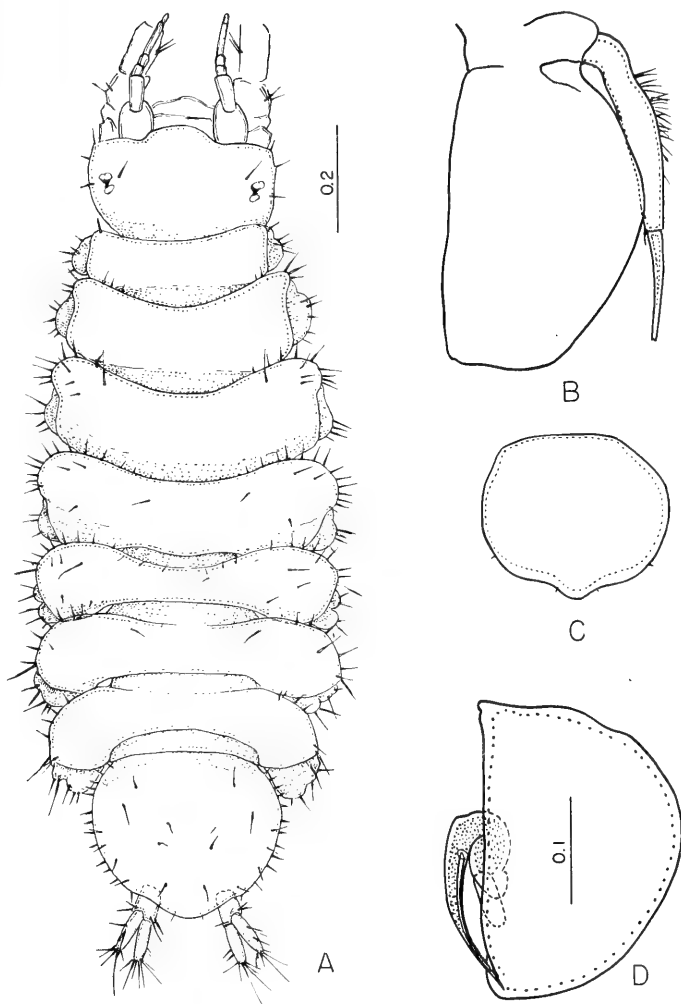


PLATE 48

Iais singaporensis Menzies and Barnard, n. sp. a, toto, male. b, fourth pleopod, female. c, female operculum. d, second pleopod of male. Figures with similar magnification: a, c; b, d. (Philippine Isls.).

5. *Iais pubescens* (Dana).

Chilton, 1892, pp. 266-267 (New Zealand); 1925, p. 319 (New Zealand).

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Monod, 1931, p. 1 (Douala Bay, Cameroun).

Stebbing, 1904, p. 10 (Negombo, Ceylon); 1917, p. 446 (Durban Bay, South Africa).

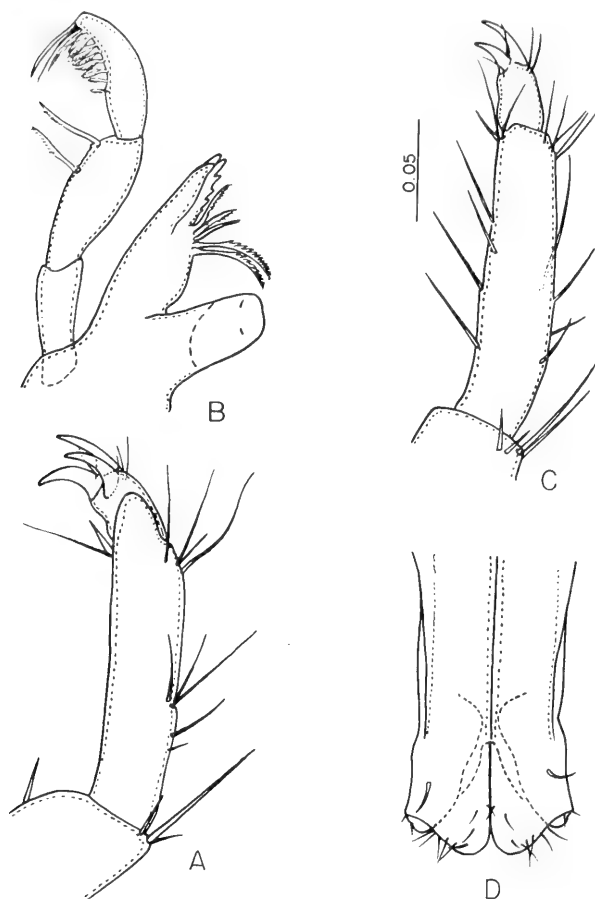


PLATE 49

Iais singaporensis Menzies and Barnard, n. sp. a, seventh peraeopod. b, right mandible. c, first peraeopod. d, male first pleopods. All figures with similar magnification. (Philippine Isls.).

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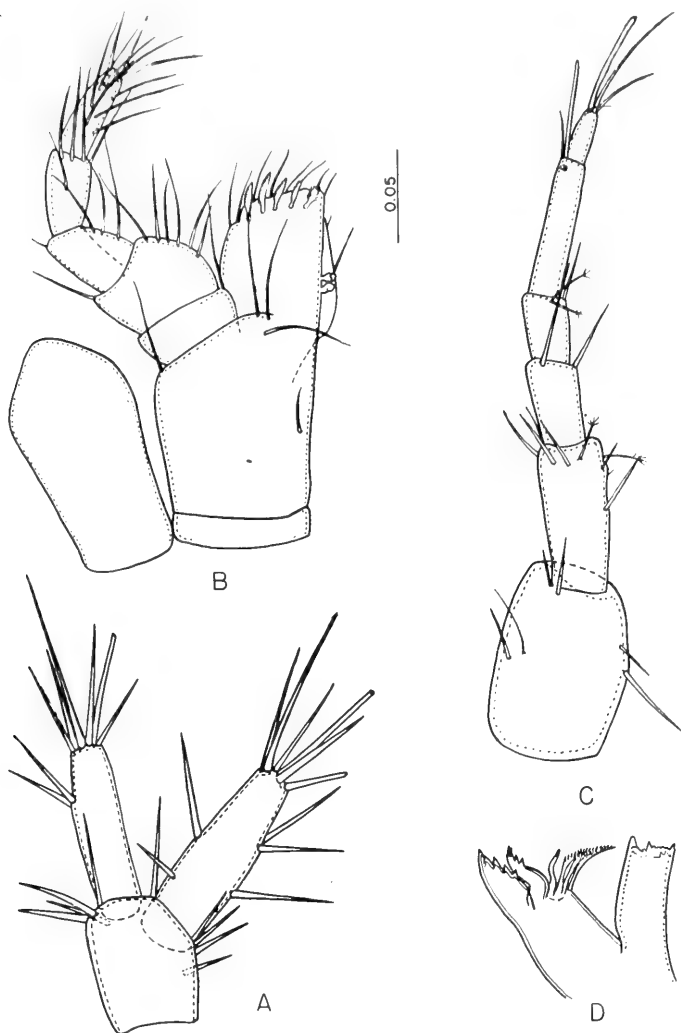


PLATE 50

Iais singaporensis Menzies and Barnard, n. sp. *a*, uropod. *b*, maxilliped. *c*, first antenna. *d*, left mandible. All figures with similar magnification. (Philippine Isls.).

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DESCRIPTIONS OF TWO NEW SPECIES OF MARINE
GASTROPODS FROM WEST MEXICO
AND COSTA RICA

By LEO GEORGE HERTLEIN and A. M. STRONG

Studies of west American marine gastropods in the collections of the California Academy of Sciences have revealed the presence of two species which appear to be undescribed. One of these represented by seven specimens, referred to the genus *Acmaea*, was presented to the Academy in 1942 by Mr. and Mrs. Harry R. Turver then residing in Santa Cruz, California, now in South Gate, California. The other species, referred to the genus *Alvania*, was presented to the Academy in 1951 by Dr. Herman W. Miller, formerly a resident of San José de Costa Rica, now residing in Santa Clara, Cuba. These species are here described and illustrated.

The photographs were made by Mr. Frank L. Rogers.

ACMAEA TURVERI Hertlein & Strong, new species

Plate 51, Figures 1, 2 and 3

Shell rather small, broadly ovate, somewhat flattened, the apex situated anteriorly about two thirds the length of the shell; exterior surface mottled grayish-green and brown, sculptured with 10 low radiating ribs which scallop the margin, the entire surface bearing very fine concentric and radiating striae; interior with shallow grooves corresponding to the ribs, the apex with a pale orange spot surrounded by a narrow bluish band encircled by a similar pale orange band, in all occupying a little less than one half of the interior surface, the remainder, pale bluish except for a dark border at the margin. Dimensions of the type: length, 18.3 mm.; width, 16.0 mm.; height, 4.2 mm.; apex situated 11.9 mm. from the posterior end.

Holotype, No. 9533 and Paratypes, Nos. 9534, 9535, 9536, 9537, Calif. Acad. Sci. Dept. Paleo. Type Coll., from Loc. 31653 (C. A. S.), Punta Colorado near Guaymas, Mexico; Mr. & Mrs. Harry R. Turver colls.

The outer portion of the interior of some of the paratypes is nearly white with the dark border reduced to dark spots in the interspaces between the ribs.

There is uncertainty as to whether or not the present specimens are referable to the genus *Acmaea* or to *Patella*. The shells are thin, with very little thickening of shell material in the apical region of the interior. The shells of most species referred to *Acmaea* are ornamented with a strongly developed "owl"-shaped patch of color in the central portion of the interior. Such a distinct shape of the color pattern is almost completely lacking in the present specimens.

Specimens of the new species differ from juvenile shells of *Patella mexicana* Broderip & Sowerby,¹ a species which has been

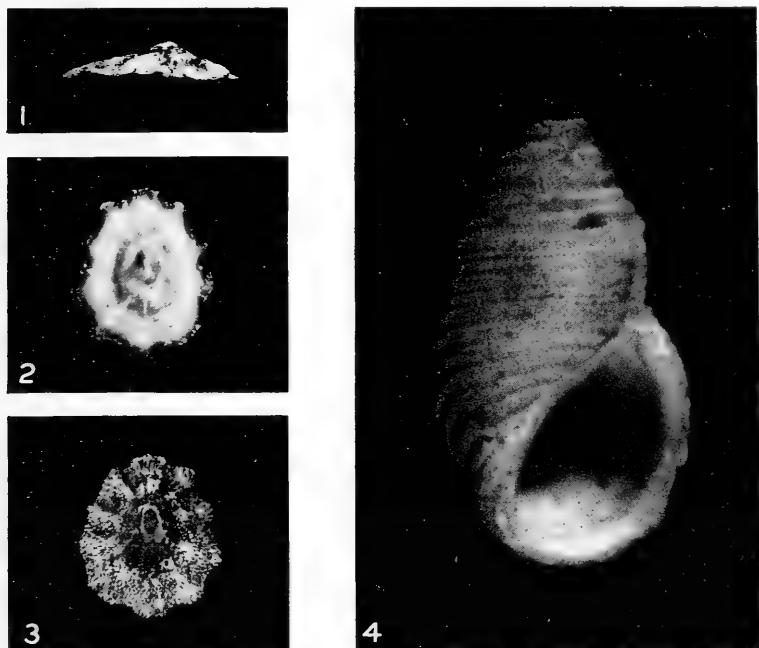


PLATE 51

Figs. 1, 2, 3. *Acmaea turveri* Hertlein & Strong, new species. Holotype, No. 9533, Calif. Acad. Sci. Dept. Paleo. Type Coll., from Punta, Colorado near Guaymas, Mexico. Length, 18.3 mm.; width, 16.0 mm.; height, 4.2 mm.

Fig. 1. Side view. Fig. 2. View of interior. Fig. 3. Apical view.

Fig. 4. *Alvania milleriana* Hertlein & Strong, new species. Holotype, No. 9538, Calif. Acad. Sci. Dept. Paleo. Type Coll., from Ballena Bay, Costa Rica. Length, 3.8 mm.; maximum diameter, 2.1 mm.

¹*Patella mexicana* Broderip & Sowerby, Zool. Jour., Vol. 4, No. 5, January, 1829, p. 369. "Hab. ad littora Oceani Pacifici." "From Mazatlan." Mexico. Reeve, Conch. Icon., Vol. 8. *Patella*. May, 1855, sp. 1, pl. 1, fig. 1.—Pilsbry, Man. Conch., Vol. 13, 1891, p. 108, pl. 31, figs. 59, 60, 61, 62.

recorded as occurring from the Gulf of California to Paita, Peru, in that they are thinner, broader in proportion to the length, in that they are sculptured with fewer ribs and in possessing a dark border on the margin of the interior.

The shell of the species here described as new differs from that of *Acmæa conus* Grant² in that the shell is flatter, it lacks minor ribs in the interspaces between the major ribs, the central portion of the interior is not thickened with shell material and the orange and blue coloration of the interior is quite different from the dark coloration of *A. conus* or *A. scabra* Gould.³

This species is named for Mr. Harry R. Turver of South Gate, California.

ALVANIA MILLERIANA Hertlein & Strong, new species

Plate 51, Figure 4

Shell very small, elongately ovate, white; nuclear whorls two and one half, well rounded, smooth; postnuclear whorls four, well rounded, with distinct sutures; principal sculpture consists of strong, equal, spiral cords of which two appear on the first postnuclear whorl, increasing to six on the penultimate whorl, in the interspaces between these cords many fine axial riblets appear but do not cross the summit of the ridges; periphery and base well rounded and sculptured similar to the spire with equally spaced cords and riblets; aperture oblique with the posterior angle obtuse, outer lip thickened, inner lip stout, strongly curved, reflected over and appressed to the base. Dimensions of the type: length, 3.8 mm. maximum diameter, 2.1 mm.

Holotype, No. 9538, Calif. Acad. Sci. Dept. Paleo. Type Coll., from a beach in the corner of Ballena Bay, Costa Rica, where the western end of the inner shore line turns toward the open sea; Dr. Herman W. Miller collector.

The sculpture of the shell of this species is not typical of the genus *Alvania* but the general character of the shell would seem to justify placing it in this genus at least for the present. One west American species, originally described as *Rissoa albolirata*

²*Acmæa cona* Test, in Light, Lab. & Field Test in Invert. Zool. (Stanford Univ. Press: Assoc. Students Store, Berkeley, 1941; pl. 12, figs. 20, 30; pl. 13, fig. 3; pl. 14, figs. 5, 6.—(Grant) Test, Nautilus, Vol. 58, No. 3, January, 1945, p. 92. "The type series is a group of 20 specimens taken personally at Point Fermin, San Pedro, California." Range, Point Concepcion, California, to Cape San Lucas, Lower California, and the Revillagigedo Islands, Mexico.—Test, Nautilus, Vol. 58, No. 4, April, 1945, p. 144. [Correction of specific name "*cona*" to "*conus*."]

³*Patella* (*Lottia*?) *scabra* Gould. Proc. Boston Soc. Nat. Hist., Vol. 2, July, 1846, p. 152. "Hab. San Francisco." California.

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Carpenter,⁴ with somewhat similar sculpture, was placed by Bartsch in the genus *Alvania*. The species here described as new differs from Carpenter's species in that the spire is much lower and the axial riblets are less numerous.

This species is named for Dr. Herman W. Miller, of Santa Clara, Cuba, who collected the type specimen.

⁴*Rissoa albolirata* Carpenter, Ann. & Mag. Nat. Hist., Ser. 3, Vol. 13, p. 477, June, 1864. Reprint in Smithsonian. Miscell. Coll., No. 252, 1872, p. 216. "Cape St. Lucas." Lower California.—Bartsch, Proc. U. S. Nat. Mus. Vol. 41, No. 1863, 1911, p. 338, pl. 29, fig. 6 (as *Alvania albolirata*).—I. S. Oldroyd, Stanford Univ. Publ. Univ. Ser. Geol. Sci., Vol. 2, Pt. 3, 1927, pl. 80, fig. 6 (as *Alvania albolirata*). (Not in text).



A NEW SONORELLA FROM THE CHIRICAHUA MOUNTAINS, ARIZONA

By WENDELL O. GREGG

Mr. M. L. Walton and the writer made a rather hurried collecting trip through southeastern Arizona in March, 1948. It was on this trip, while passing through the foothills on the northeast side of the Chiricahua Mountains, that we first noticed some low granitic cliffs on the north side of the Portal-to-Paradise road about three miles west of Portal. The rocky hillside below the cliffs appeared to be a likely place to find land snails, but since our time was limited, we stopped only at localities with published collecting records.

On our return to the Chiricahuas in October of the same year, we spent some time at this locality looking for land snails and were rewarded by finding *Holospira arizonensis* (cf) *emigrans* P. & F., *Thysanophora horni* (Gabb), and a *Sonorella* which quite obviously has been overlooked by other collectors. A fair series of the *Sonorellas* were found, most of them in quite good condition, though we failed to find any living specimens. One year later Mr. Walton and I revisited this place. This time two hours at turning heavy rocks failed to reward us with living specimens though an excellent series of snails in good condition was collected.

In spite of the extensive collecting done in these mountains by Pilsbry, Ferris, Daniels, and others, I fail to find any record of collecting done at this station.

Since this *Sonorella* seems quite distinct from any described form, it seems appropriate to name it at this time. It may be known as

Sonorella neglecta new species.

Plate 52

Shell small for the genus, depressed-conic; whorls $4 \frac{1}{3}$, convex, increasing gradually to the last whorl which expands moderately and descends moderately behind the aperture; base rounded, the umbilicus contained about $7 \frac{1}{3}$ times in the greater diameter of the shell. Aperture oblique, rounded-oval; peristome slightly expanded and slightly thickened, the columellar end dilated and covering the margin of the umbilicus. A thin parietal callus is present.

Embryonic shell consists of 1 1/2 whorl; the apex smoothish, followed by a radially wrinkled area which continues to the end of the first half whorl; the next half whorl wrinkly-granulose with forwardly descending and ascending delicate threads at regular intervals superimposed; the last half whorl of the embryonic shell wrinkly-granulose with elongate papillæ. The first neanic whorl marked with close growth wrinkles, indistinct granulation, and scattered papillæ; the remaining whorls smooth and marked only with fine growth striæ.

Color light Sayal Brown fading to whitish around the umbilicus and with occasional radial whitish streaks. A peripheral chestnut band 1 mm. in width is bordered above and below by somewhat narrower bands lighter in color than the body of the shell.

Maximum diameter 16.1 mm., minimum diameter 13.0 mm., altitude 9.2 mm., umbilicus 2.2 mm., whorls 4 1/3.

Type locality: Rocky hillside below granitic cliffs, north of Portal-to-Paradise road about 3 miles west of Portal, Chiricahua Mountains, Cochise County, Arizona. Altitude about 5,300 feet.

Holotype No. 5317, author's collection. Paratypes in collections of the Los Angeles County Museum (No. 1087), S. S.



PLATE 52

Sonorella neglecta Gregg. Holotype, X 2.

(Photos courtesy Los Angeles County Museum.)

Berry (No. 16579), M. L. Walton, and the author (Nos. 4640 and 5312).

Additional Localities: Steep rocky slope of eastern hill of low range running west opposite mouth of Cave Creek Canyon, 100 yards west of pumping station of A.V.A. Ranch, Cochise Co., Arizona, May 14, 1951, M. L. and D. M. Walton, Collectors. This locality is about 1/2 mile west of Portal and about 2 1/2 miles east of the type locality.

A single specimen in rather poor condition, which seems referable to *S. neglecta*, was found on a rocky isolated hill .8 mile east of the junction of the Whitetail Canyon road with the road to Paradise. This is 7.1 miles west of the type locality.

The sculpture of the embryonic shell suggests relationship with the *Sonorella hachitana* group. However all described forms of that group are considerably larger than *neglecta*. Snails of the *Sonorella binneyi* group are generally more globose. *Sonorella boreiensis* Pils. is larger, has a proportionately wider body whorl and the whorls are more flattened above. *Sonorella delicata* Pils. & Fer. is slightly larger and differs in having nearly smooth embryonic whorls. However, until live snails are found and the anatomy of the reproductive system studied, no conclusion can be drawn as to the definite relationship with other members of this genus.

The paratypes of *neglecta* are relatively uniform in size and shape. One paratype is somewhat smaller than the others. Maximum diameter 13.5 mm., minimum diameter 11.8 mm., altitude 8.8 mm., umbilicus 2.0 mm., whorls 4 1/2.

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FOUR SOUTH AMERICAN GEOMETRID MOTHS
APPARENTLY UNDESCRIBEDBy JOHN L. SPERRY
Riverside, California

It is with a certain feeling of inadequacy that the author undertakes this paper. During the past ten years as time has permitted, the author and the late Mrs. Sperry have been working with the lepidoptera of South and Central America and as a multitude of information accumulates the author feels even more that his knowledge of the Neotropical fauna is entirely inadequate. Nevertheless a beginning has to be made and as there are a few among the many unknowns which seem to be definitely undescribed, the author makes bold to give these a name and at the same time to tender his thanks to Dr. J. F. Gates Clarke of the U. S. National Museum who so kindly sent the species from Chile and to Mr. D. S. Fletcher of the British Museum staff who has so kindly checked these species for us and who is directly responsible for much of the author's South American Geometrid information.

CALLIPIA BRENNEMANÆ, sp. n.

This is a bright and striking Larentid, belonging in Warren's subfamily Eucestiinae and closest (as Mr. Fletcher has pointed out) to *Callippia constantinaria* Ober. from Peru.

Head, front, palpi and simple antennae black with a slight brownish cast. Palpi rough scaled, porrect, about $1\frac{1}{4}$ the diameter of the eye, third joint close scaled. Prothorax black, hairy, with lateral tufts of orange hair, orange beneath. Meso and meta thorax with latero-dorsal tufts of long tan-gray hair. Abdomen sparsely scaled, fuscous above, black beneath with orange blotches laterally, low on the second, third and fourth segments. Legs gray-black, femur shortly and densely hairy. Forewings: Costa, light pinkish cinnamon, more or less mottled with black in a strip slightly over 1 mm. in width; rest of wing dark gray-black with the exception of the large orange blotch, about 15 mm. x 18 mm. which covers much of the basal and median areas. The border of this orange area begins at the base of the wing, follows the costal edge of the cell to vein 6, thence curves in the arc of a circle to a point 1 mm. above vein 1, approaching to about 3 mm. from outer margin and reaching the point above vein 1 at about that distance from the tornus, thence back parallel to vein 1 to the base. The

lower edge of the cell to a point beyond vein 4 is more or less heavily edged on both sides of the vein with black with slight excursions, especially in the ♀, out along veins 2 and 3. Fringes short, concolorous with the black part of the wing; no discal dot,

Hind wings: Immaculate, dark mouse gray, fringes concolorous. Discal dot absent.

Beneath: Orange area on forewing as above, costa and apical area above vein 6, honey yellow, merging into light cinnamon-brown, rest of wing as above.

In the ♀ the honey-yellow area more extended than in ♂. Hindwings have a black ground color with cream white veins and many fine white lines arranged in pairs perpendicular to the veins, crossing and irrorating the entire wing. These fine white lines are closely merged into an irregular bar beyond the cell between veins 1 and 4. Above line 4 part of the black ground color is replaced by cinnamon, giving the wing a marbled appearance. Fringes mouse gray, discal dot absent.

Expanse ♂ 45 to 50 mm., ♀ 52 to 55 mm.

Holotype, ♂. Yungas del Palmar, Bolivia, 2000 m., Mar. 15, 1949 and in the Sperry collection.

Allotype, ♀. Same data Mar. 30, 1949 in the Sperry collection.

Paratypes: 8 ♂, 3 ♀, same locality, Sept. 1948 and Apr. and Feb. 1949 and Chapare, Bolivia, Dec. 8, 1949 Peña coll. and in the United States National Museum, British Museum, the Ham collection in Enterprise, Oregon and collection Sperry.

This species is closest to *constantinaria* Ober. of which species Mr. Fletcher has kindly sent me 2 ♂ for comparison. These are easily separated, as the shape of the orange area on the forewing differs constantly. In *constantinaria* this starts as in *brenemanae*, follows the costal edge of the cell to vein 4 then curves down to or shortly beyond vein 2, thence along or parallel to vein 2 to the cell and so back to the base, making a smaller, narrower and more angular orange area.

The author has only examined the ♂ genitalia and the acquiring of ♀ specimens may show this species to be a Bolivian form of *constantinaria* for the ♂ genitalia offers few good differences. In *brenemanae* the ampullæ are shorter and chunkier and the open space at the base of the valvæ is pointed toward the spine at the tip of the sacculus instead of being rounded as in *constantinaria*.

It is with deep appreciation that the author names this fine species in honor of Mrs. Dorothy Jean Breneman Ham, of Enterprise, Oregon.

Artist, craftsman and scientist in her own right, she, with her husband, Dr. Lyle C. Ham, took the author into their home and hearts and did more than any other persons to make it possible for him to carry on during the black days following Grace's passing.

The author has in the Sperry collection a single specimen of what is probably an environmental form of *Callipia constantinaria* Ober. The latter and the Bolivian specimens of *brenemanæ* are taken at altitudes above 2000 m. This specimen is from the edge of the jungle at a lower altitude and is distinguished by its smaller size (44 mm. to about 52 mm. for *constantinaria*) the jet black ground color of both wings as compared with the distinct brownish cast of *constantinaria* and the shape of the lower border of the orange area which goes from the lowest point of the curve at vein 2 directly to the base without following the vein to the cell. Expanse 44 mm. The author suggests for this form the name HAMARIA.

Holotype: ♂, Satipo, Peru, May 1948 Pedro Paprzycki, coll. and in the Sperry collection.

The author takes great pleasure in naming this bright form in honor of Dr. C. Ham of Enterprise, Oregon. Doctor, scientist, councilor and friend in great need.

SPARGANIA RANDALLÆ, sp. n.

This Chilean species looks close to the genus *Anapalta*, Warr. excepting for the double areole on the forewing and the tiny cilia on the antennæ. The ♀ genitalia however places it in or close to the genus *Spargania* Guenee.

Female: Palpi short $1\frac{1}{4}$ the diameter of the eye, porrect or with third joint upturned, third joint close scaled, rest rough scaled black and white. Front sandy with brown, black and white scales. Vertex and collar white. Antennæ white, ringed with narrow, brown bands, simple, lightly ciliate. Thoratic vestiture scales mixed with long hairs, mostly white with black specklings. White below. Abdomen dark dorsally with small white spots on each segment, laterally and beneath white. Legs close scaled, mostly white with specklings of black dots.

Forewings: The basal area, 1 mm. wide is white, the outer edge with an outward scallop below costa and in cell. Basal band fuscous, 1 mm. wide and followed by a slightly lighter area of the same size, both with irregular margins, the bands narrowing at inner margin. The median fascia is violet fuscous and extends on the costa to within 3 mm. from the apex, its outer edge rund

perpendicular to costa to vein 7 thence with a deep inward scallop to vein 4, thence to inner margin 3 mm. in from tornus.

There is a median broken band of white in the fascia; the upper looks like a horse's head with the neck at the costa, short ears toward the outer margin and nose between lines 2 and 3 below the cell. The eye is a long dark discal dash. There is a tiny white spot below vein 2 and a larger one at vein 1; a still larger spot is centered on the inner margin. These are ringed with fuscous and paralleled with outer dark lines. The subterminal area is lighter with heavy speckling of fuscous and broken parts of a dark subterminal line, strongest near the inner margin. There is a narrow fuscous, terminal line. Fringes white with dark mottling.

Hindwings: White, sparsely peppered with fuscous scales, especially in subterminal area. T.p. line indicated by dim, fuscous dots on the veins.

Fringes white. Discal dot below showing through.

Beneath: Forewings dull fuscous with outer edge of median fascia indicated by a lightening of the scaling, subterminal area lighter than the rest of the wing. Discal dash and terminal line present. Fringes as above.

Hindwings white. T.p. line of fuscous scallops with points inward on the veins. Discal dash strong. Fringes as above. Expanse 37 mm.

Holotype ♀ Pudahuel, Chile, I, '48, T. Ramirez, coll. and in the collection of the United States National Museum.

Paratype: ♀ Guayacán, Santiago Prov., Chile, 5-12, XII, 1947, Tito Ramirez, coll. and in the Sperry Collection.

It gives me fond pleasure to name this beautiful insect in honor of my wife, Bertha Randall Minor Sperry, who, having lost her dearest one, even as have I, still finds the courage to bring happiness to the last years of this entomologist.

It will require more material to place this insect accurately. The form and maculation of the wings makes it look closer to *Perizoma africana* Warr. than anything else known to the author but 6 and 7 in the hindwings are short stalked or connate and the ♀ bursa, almost bilobed, places it in or close to *Spargania* Guenee.

SALPIS CLARKEI, sp. n.

♂ ♀ Palpi moderate, about 2x diameter of the eye, second joint heavily and loosely clothed with a triangular scale and hair tuft, third joint long, its scales appressed, mouse gray. Front slightly bulging, clothed loosely with scales and hair, mouse gray.

Vertex cream. Antennæ simple in both sexes, not ciliate. Prothorax mouse gray, meso and metathorax and abdomen light gray, peppered with mouse gray scale tips; under side light gray. Legs close scaled, femur light hairy.

Forewings: Bluntly subfalcate, sharper in ♀ outer margin lightly and bluntly toothed a line 6, light cream gray, peppered sparsely with mouse-gray scales from base to discal spot, mouse-gray beyond to outer margin.

There are traces of a broken t.a. line accentuated by dark dots on vein 1 and the cell, and a dim line between costa and cell angling backward toward the base. Discal dot distinct and annulate. T.p. line from $\frac{3}{4}$ out on costa is marked by small dark dots on the veins, it is subparallel to outer margin. Terminal dark dots between the veins. Fringe concolorous with outer area.

Hindwings: Cream gray, small annulated discal spot. T.p. line, $\frac{2}{3}$ out from base indicated by dark dots on veins, line subparallel to outer margin.

Fringes concolorous.

Underside: Both wings light gray, in ♀ dusted with fuscous, dark discal dots and a line of black points terminally between the veins. Fringes concolorous. Expanse ♂ 42 mm., ♀ 52 mm.

Holotype, ♂, Cajon de Maypo, Santiago Prov., Chile Cordillera, El Canelo, 12-20, I, 1948 Tito Ramirez, coll. and in the collection of the United States National Museum.

Allotype: Same data and in the Sperry Collection.

This species belongs in the subgenus I of Prout although the hind tibia of the ♂ lacks the hair pencil and is not swollen. The species would seem to be close to *ænea* Butler but lacks the heavy discal spots and terminal black line, the swollen hind tibia of the male and hair pencil.

Also the margins of the wings in both sexes are only slightly toothed.

It is indeed a great pleasure to name another fine moth in honor of my good friend, Dr. J. F. Gates Clarke of the U. S. National Museum, in grateful memory of many kindnesses both past and present, extended to the author over many years.

THE FRAGILITY FACTOR FOR *TRYPANOSOMA CRUZI* IN EXPERIMENTAL CHAGAS' DISEASE¹

By SHERWIN F. WOOD²

Life Sciences Department
Los Angeles City College, Los Angeles 29, California

From the large number of parasite remnants seen on well prepared blood smears, the writer agrees with Brumpt (1949) that *Trypanosoma cruzi* is "tres fragiles." While engaged in a study of blood types of this trypanosome, counts were made to determine the fragility factor for NIH Brazilian strain trypanosomes.

Clean slides were placed upon a black topped laboratory table 45 mm. beneath the nearest curvature of a blue, smooth-surfaced, HyGrade, 60 watt light bulb in a goose neck desk lamp having a 6½ inch half-globe reflector with aluminized inner surface. As slides immediately beneath the bulb were used, others were pushed over to replace them. Thus, the warmest slides were used as needed. Laboratory thermometers placed flat upon the table with the bulb directly beneath the light varied from 71°C to 77°C depending upon the shape of the mercury bulb. Room temperatures at the time these preparations were made varied from 19°C to 25°C. Thus, the heat-fixed slides refer to those made on pre-heated slides whereas the air-dried smears were made on slides at room temperature. Actually, air-dried refers to a degree of heat which varies from cool to very warm sensible temperatures.

Table 1 shows the comparative values for several experimental white mice, *Mus musculus*, inoculated intramuscularly (left and right gastrocnemius) with the NIH Brazilian strain. Parasite remnants are spotted easily in Jenner-Giemsa stained smears by the intact axoneme, near which can be found basket-like meshworks of the kinetoplast and nucleus. Thus, as indicated in the table, the fragility factor of 9.9% for experiment 159 on the 23rd day shows that 99 trypanosome remnants were found in the first thousand parasites encountered.

Counts were made on blood smears prepared on days when more than 500 parasites were seen in two drops of fresh tail blood under an 18 mm. circular coverglass. Most counts of 1000 trypanosomes, including remnants, were confined to the beginning 10 mm. of the blood smear. However, in experiment 169, the whole smear of 286 sq. mm. yielded only 708 parasites. As noted in the table, on one smear for experiment 165, three counts were

¹This research was supported by a grant from the U. S. Public Health Service.

²Visiting Scholar, 1950-51, Division of Zoology, University of California at Davis.

made in three areas for the 29th day slides, and for experiment 181, two counts were made in two areas for the 38th day smear.

In experiments 162 and 165, the heat-fixed slides were smeared first, whereas in experiment 181 the air-dried slides were smeared first. The tail was clipped with a razor-sharp scalpel. The first two drops were placed on the slides and smeared immediately. Since thickness of the blood smear is related to fragility, measurements with the calibrated fine adjustment on the heat-fixed slide for experiment 165 revealed thicknesses of 7.5u, 5.0u, and 2.5u for beginning, middle, and end areas, respectively.

Possibly the few seconds delay in smearing the droplet on the heated slide in experiment 181 may account for the higher fragility factors noted there. On the first half of heat-fixed slides of experiments 162 and 165, one could assume that the percentage of structural types found near the beginning edge of the smears would be representative of the circulating tail blood at that particular time of the infection because of the low fragility factor.

Thin smears are best for studying detail of these structural types but give a distorted picture of relative proportions of blood types due to greater breakage of trypanosomes. Thick smears preserve all types well but render them more difficult to recognize since cytoplasmic details are obscured by the more compact body form and less differential staining.

Although the results presented here are inconclusive, there is some indication that heat fixation of medium thick smears controls the excessive breakage of individuals of *Trypanosoma cruzi* in the first half of the blood smear.

REFERENCE

Brumpt, E.

1949. Précis de Parasitologie (Paris: Masson et Cie), Vol. 1, 1042 pp.

TABLE I

BLOOD SMEAR FRAGILITY FACTORS FOR *TRYPANOSOMA CRUZI*

(Percentage of broken trypanosomes per thousand)

Experiment Number	Air Dried	Heat Fixed	Area of Smear	Day after Inoculation
159		9.9	Beginning	23
162	9.9	3.2	Beginning	21
	2.8	1.5	Beginning	29
	1.3	0.0	Beginning	35
164		33.5	Beginning	19
165	2.3	0.4	Beginning	29
	38.8	1.0	Middle	29
	85.2	57.4	End	29
169	50.2		Whole (708)	28
181	11.2	11.5	Beginning	28
	20.3	28.9	Beginning	34
	0.4	1.1	Beginning	38
	88.5	68.6	Middle	38

WHAT SIGNIFICANCE DEPTH?

By PHIL C. ORR

Santa Barbara Museum of Natural History

It is customary to record the depth at which artifacts or burials are recovered. In many field records, such "data" as: "Depth 27 inches" is included without any supplementary information to indicate whether the surface is undergoing erosion or deposition. Was this object originally on the surface, and has 27 inches of deposition taken place since, or was it at a greater depth and has erosion reduced the overburden to 27 inches? Fortunately, some archeologists include supplementary data or when stratigraphy is present, record materials from the various strata; but too often, the word "stratum" is used unconsciously as a synonym for "depth" for the reason that excavations are not of sufficient extent to expose the complete record of the change in structure.

Along the Santa Barbara coast in California are over one hundred Indian middens of the Oak Grove, Hunting People and Canalino cultures, which after one hundred years of extensive plowing by the white man have come to have very similar physical appearances. This appearance, typical of mounds in Southern California coastal region, is one of low arched shell deposits on slightly higher ground than the surrounding area. Physically, the mounds vary in size from a few yards to a quarter of a mile, and in depth from a few inches to ten feet. In general, they are slightly arched, being deeper in the center and thinning out on the edges. (Plate 53, C).

It is natural to visualize the mounds as being essentially the same now as when they were occupied, with the exception, of course, of the dome-shaped grass houses. In all probability, a new village on sterile soil did give such an appearance, but the results of excavations of the Santa Barbara Museum of Natural History on San Nicolas Island, and especially on Santa Rosa Island, give us an entirely different picture of the occupancy and deposition of a Canalino village. On the islands there has been no plowing of the fields by white men. Only nature has contributed to the destruction of the original villages as left by the Indians one hundred fifty to four hundred years ago. At Skull Gulch on Santa Rosa Island, about fifty well-preserved house pits are found, which average about forty feet from rim to rim of the circular depressions, and range in depth from one to six feet. It is assumed at present that this site was in use just prior to 1542 for the reason that limited numbers of glass beads are found.

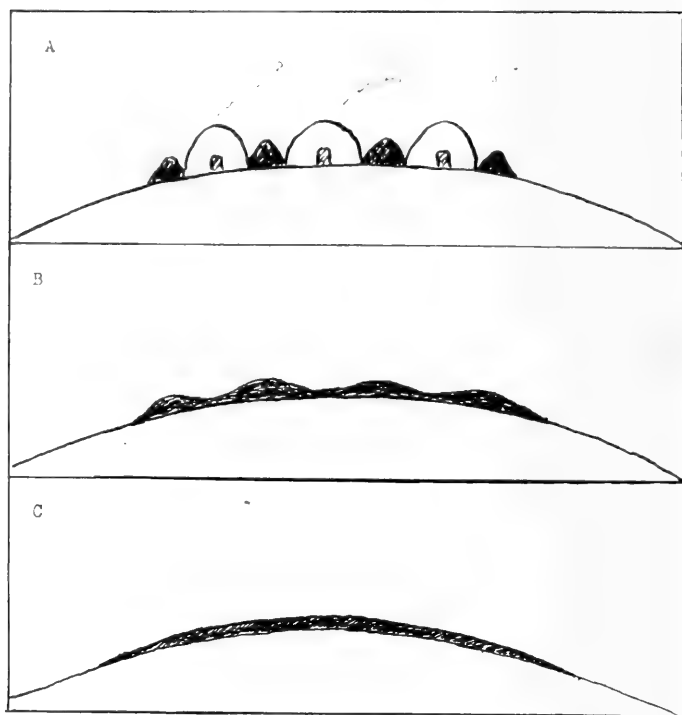


PLATE 53

Diagrammatic cross section of three stages of South Coast middens.
a, Inhabited village. b, Abandoned village. c, Prehistoric village leveled by erosion.

Let us picture for a moment a Canalino couple selecting the site for their new home:

The ground is level, clay or sand, with perhaps a few broken shells and charcoal from the nearby houses. Post holes are dug and the supporting poles of the house erected and covered with sea grass. Perhaps, on their anniversary, papa gave mamma a strand of genuine *Olivella* beads, which for simplicity's sake we will refer to in Plate 54 as "A." There comes a little Canalino who snatches mother's necklace and the beads are scattered. Some are recovered, others are later swept up in the ashes and loose dirt on the floor of the hut and thrown outside the house in a basketful of *Mytilus* shells from Sunday dinner.

Years go by, during which time more *Mytilus*, together with ashes, *Haliotis* shells, the well-gnawed femora of sea otter and

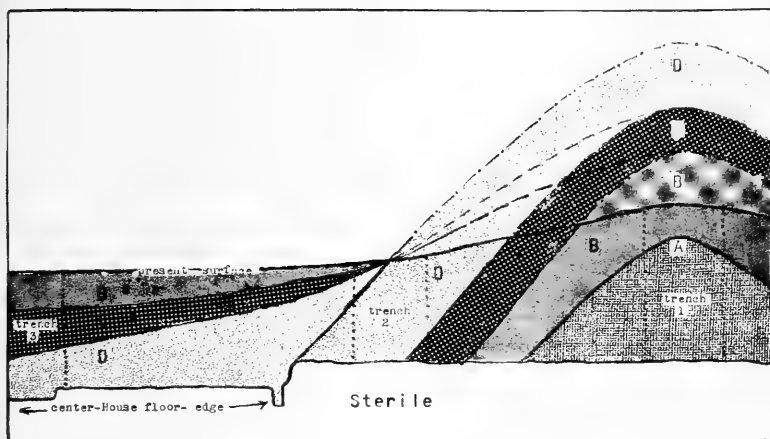


PLATE 54

Cross section of center to edge of a house pit. Dotted lines on right show original structure of midden before the upper layers were redeposited over the house floor (left).

sea lion, together with fish scales and bones and the refuse pile beside the house grows, burying the few lost beads deeper and deeper. Let us assume the baby has also grown and is now a young woman, wearing the latest thing in neckwear imported from Santa Catalina—genuine unmatched steatite beads—which we will call “B.” Strings will break and a few of the lost beads find their way to the top of the pile.

Let us hurry by another generation and assume that the young woman who broke her mother’s “A” beads and who lost her own prize “B” beads gives her daughter a brand new string of clam disc beads (C) which all the girls are now wearing. Beads have changed but strings still break and granddaughter’s new “C” beads find their way to the top of the ever-growing pile outside the house. To hurry by another generation, some glass beads (D) are given to the great-granddaughter by the strange white man, Cabrillo, and eventually some of them find their way to the top of the pile.

If an archeologist could now section the midden, he would find everything very orderly (Plate 54). The Late glass beads of great-granddaughter would be on top. Further down, say 10 inches, would be granddaughter’s lost clam beads (C) while near the middle, daughter’s steatite beads (B) would be found and

below them, near the bottom of the pile, mother's *Olivella* (A) would lie.

Five hundred or a thousand years is a long time and the house has since collapsed and decayed. Mother, daughter, granddaughter and great-granddaughter have long since been laid in a flexed, face-down position with appropriate blowing of smoke to the four corners. Wind and weather have now reduced the huge heaps of debris surrounding the old house site to a low, undulating mound (Plate 53, b.), or, if we give it time enough and add the white man's cultivation, it will be reduced to a low arched mound along with the other huts of the village (Plate 53, C).

Our archeologist puts down a trench, four feet wide and perhaps eight feet long, near the center of the heap outside the house, and records mother's "A" beads, as near the surface (Plate 54, trench 1). He sinks another trench on the edge of the site where the old house stood and finds no "A" beads, but does find "B" and "C" near the surface and "D" all the way to the bottom (Plate 54, trench 2). He then puts down a third trench near the center of the house (Plate 54, trench 3) and finds B, C and D beads near the surface, C and D below them, and near the bottom great-granddaughter's D beads only. Now what does he have? He may reason that since A, B, C and D have been found on the surface, these are "Late" traits and that as glass beads, D, were found from top to bottom in two pits the entire site is contact. Why does he find these things in this relation? Because the original heap of debris on the edge of the house site weathers from top down, so that the last deposited material (D) is the first to be redeposited in the bottom of the house site. More erosion and the replaced D "stratum" is covered over with C and B "Strata."

Theoretically, there is one point, at the junction of the heap with the horizontal surface, where mixtures of the three strata are made by secondary redeposition. As a simplified explanation, the last object to be deposited is the first object to be redeposited, so that the first object to be deposited will be found over the last object but, actually, neither the original deposition nor the redeposition is as simple as that and the further the erosion progresses, the greater the complexity of redeposition.

So far, we have given an illustration of what might have happened in four generations in one 27-foot area only. We have not taken into consideration at all the ever present rodent which burrows deep holes through house sites and burials only to have the next rain wash the debris from the surface down into the holes. Nor have we considered the farmer with his plow, which may drag artifacts for a hundred yards as well as putting a surface piece 14 inches underground.

Neither have we considered Mother Nature in her most violent moods when, at locality 131.137, Santa Rosa Island, for instance, she eroded a camp site at a 50 foot elevation and redeposited it in a canyon adding, for good measure, 30 feet of sterile soil over the deposition. Such gigantic efforts, even on the part of Mother Nature, take a great deal of time, but in this case artifacts of the same original age might be found at "27 inches" or at "27 feet." Depth can be a clue to antiquity or to chronology, but it may well be a false clue, unless we recognize that what goes up must come down, and that which is deposited on top of the pile may roll or be washed to a lower level.



Elza Ellsworth Hadley

1864-1951

Mr. E. E. Hadley, paleontologist, and member of this Academy since 1937, died at his home in Alhambra on August 8, 1951. Only a few weeks before he had been busy at his desk in the Los Angeles County Museum where he had served as Honorary Curator of Paleontology since 1936.

Hadley's parents, Jonathan Doane and Zelinda Griffith Hadley, came of long American lineage of Quaker faith. Elza was born in Stewart, Iowa, on December 16, 1864, and was raised on the family farm close to rich fossiliferous deposits of Carboniferous age. As a boy of 15, young Elza began collecting fossils, but not until a year later, from a class in physical geography, had he any hint as to their significance. When he was 18 he began exchanging fossils with other young collectors, and his study of paleontology began in earnest.

Grown to manhood, Hadley married (in 1888) Maude E. Bunche, by whom he had four children. He followed in his



father's footsteps as a farmer, and later, on moving to California, became a rancher and a nurseryman. His interest in paleontology, however, was ever present; he never lost an opportunity to collect or to exchange fossils.

In California, Hadley discovered several rich deposits from which he collected a wealth of material. Most outstanding were the fishes and plants found in the Miocene shales of El Modena and Alhambra, which formed the bases for monographs by Dr. David Starr Jordan and Dr. J. Z. Gilbert (on fishes), and Dr. Ralph Chaney (plants).

Many of Hadley's specimens were loaned to the new Los Angeles Museum in 1913. Later, in 1936, his entire collection of over 2500 specimens was presented to that institution. Included in this gift were many cotypes and reverse slabs of Jordan's types.

Hadley took an active part in several of the scientific societies of Southern California. He was president of the Lorquin Natural History Club in 1915 and organized its Geological Section in 1917. In 1941 he became a charter member of the Dana Mineralogical Club, serving on the editorial staff of the Dana Magazine until 1947. In the Southern California Academy of Sciences he was a member of the Earth Sciences Committee for several years, and also served loyally on the Hospitality Committee.

Mr. Hadley's published works include a number of articles and poems printed in *Lorquinia* and the *Dana Magazine*. He modestly considered himself a collector rather than a research scientist, and at one time (1917) wrote, for *Lorquinia*, an article on the place of the collector in the field of science. This article clearly reflects the spirit which all who knew Elza Hadley observed in him—the spirit of never-ending wonder at the mysteries of nature, of humility with respect to his own attainments, and a keen desire to share his discoveries with others.



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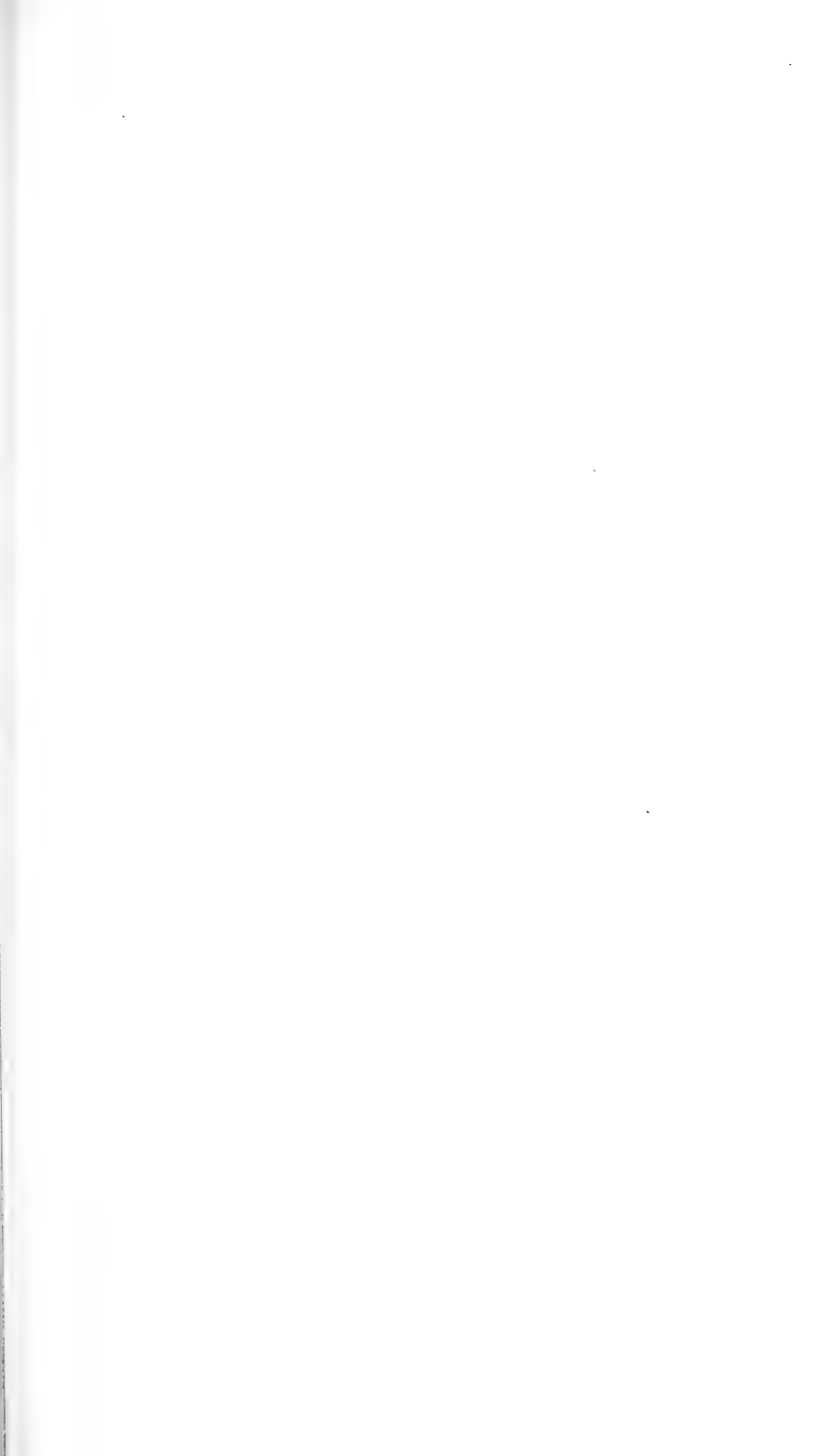
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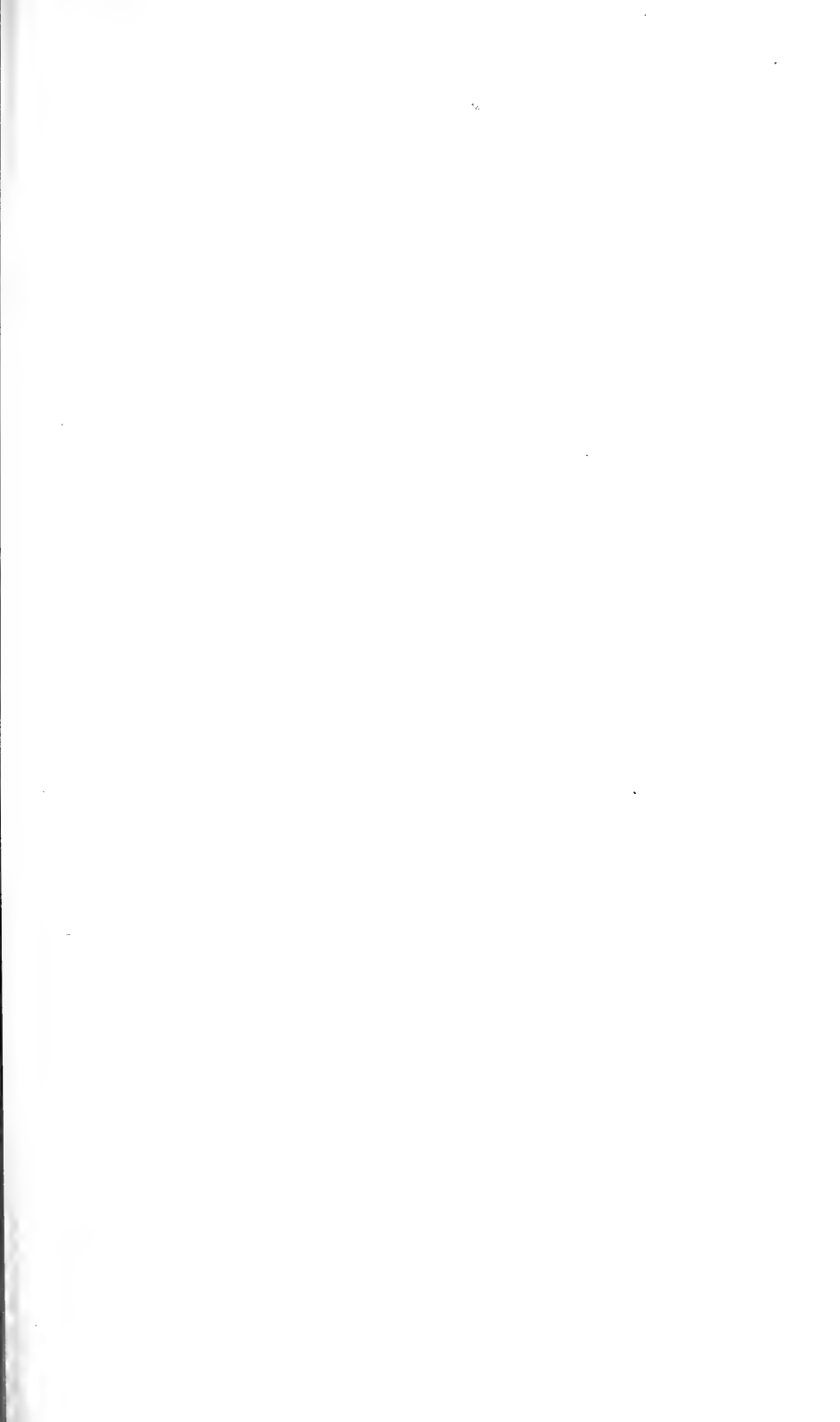
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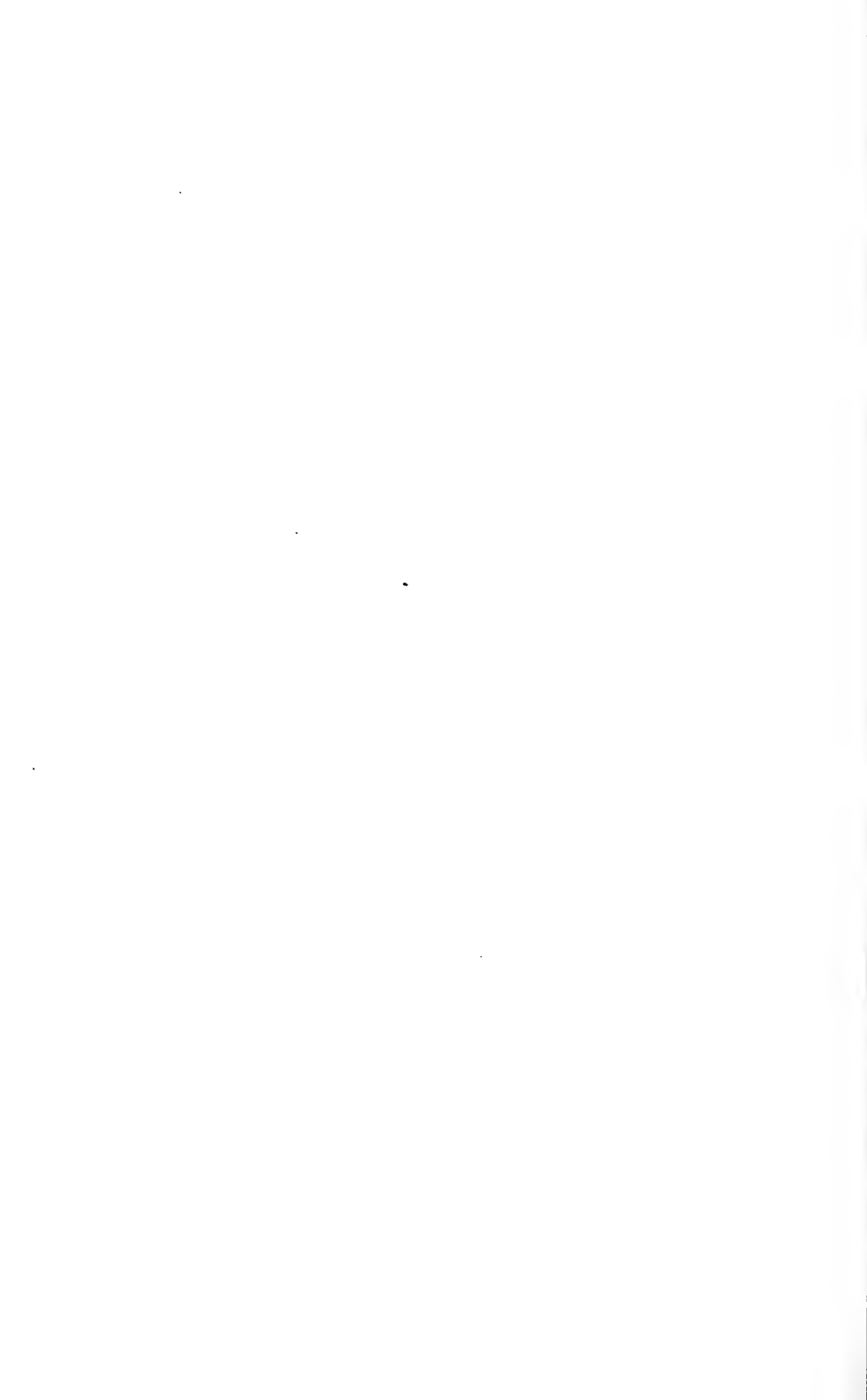
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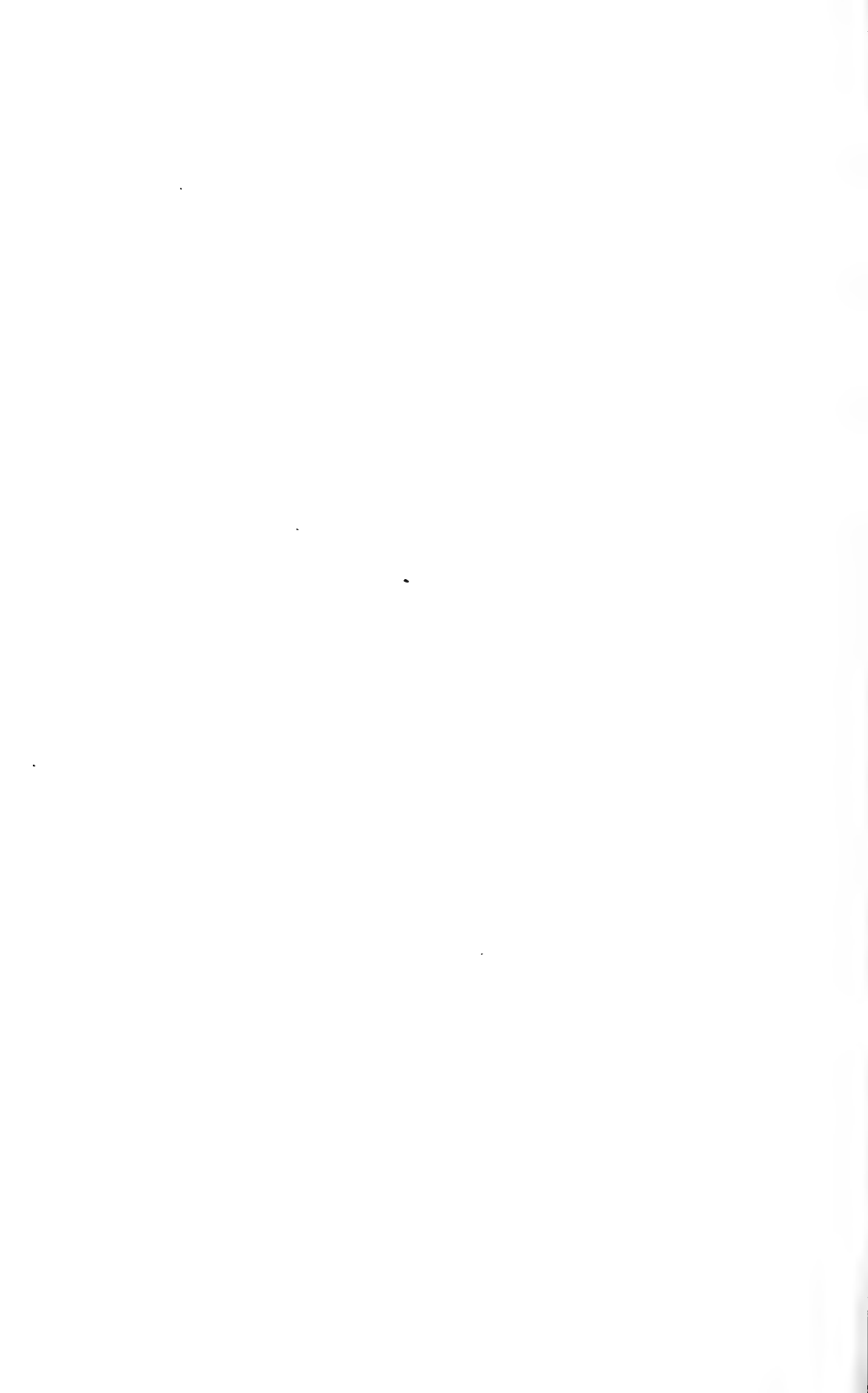


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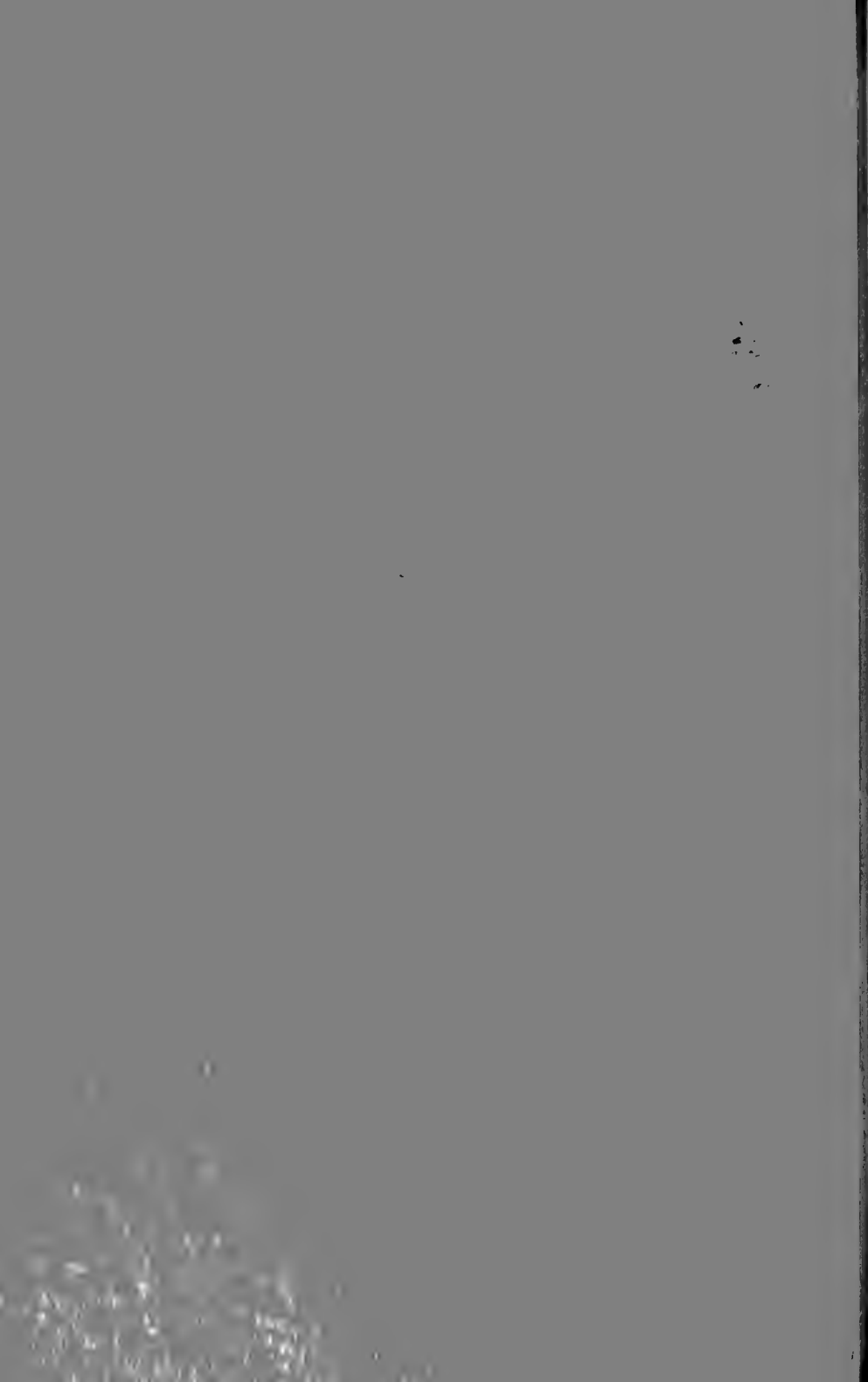
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**A NEW GENUS AND SPECIES ASSOCIATED
WITH ORCHIDS FROM MEXICO
(LEPIDOPTERA: CHRYSAUGIDAE)**

By HAHN W. CAPPS

Bureau of Entomology and Plant Quarantine, Agricultural Research
Administration, United States Department of Agriculture

For several years the larvae of a chrysaugid species have been intercepted rather frequently in shipments of orchids from Mexico. The adults reared and submitted for identification by inspectors of the Bureau of Entomology and Plant Quarantines at the ports of Brownsville and Laredo, Texas, represent a new species and a new genus.

POTOSA, new genus

Antenna simple or ciliate. Labial palpus upturned, not reaching vertex, moderately scaled below. Frons evenly rounded. MALE: Forewing (fig. 2) with costa slightly undulate; 11 veins (7 united with 8), vein 2 approximate to 3, 4 and 5 stalked, 6 from upper angle of cell. Hind wing (fig. 2) with vein 3 from slightly before angle of cell, 4 and 5 stalked; discoidals strongly curved inward; 7 stalked with 6 from cell then diverging and anastomosing with 8 a short distance. FEMALE: Forewing (fig. 1) with costa nearly straight; 11 veins (7 present, stalked with 8 and 9, 11 obsolescent); 4 and 5 stalked. Hind wing (fig. 1) essentially like that of male.

Type of genus. — *Potosa rufofascialis*, new species.

Remarks. — Related to but separated from *Dasyncnemia* Rago-¹not¹ by veins 7 and 8 of the forewing (males of *Dasyncnemia* with vein 7 separate from 8 and those of *Potosa* with 7 and 8 united). No females of *Dasyncnemia* available for comparison.

Potosa rufofascialis, new species

MALE: (pl. 1; figs. 2, 4, 4a). — Antenna ciliate; cilia short, length of cilia approximately equal width of antenna near base. Third segment of labial palpus short, not more than one-half as

¹Proceedings of the Zoological Society of London, p. 660, fig. 25, 1897.—Hampson, G. F.

long as second. Forewing: (above) reddish brown with a tinge of purple; transverse anterior and posterior lines brownish, rather indistinct, concave outwardly. Transverse anterior line from costa, distant the base about one-fourth length of wing; transverse posterior line from costa, distant the base about two-thirds length of wing. Basal area darker than median area.; (below) paler than upper surface, with the light brown more intense near costa, and the transverse and posterior lines more distinct. Hind wing: (above) reddish brown, slightly paler than forewing; post medial line indistinct; (below) post medial line distinct, somewhat serrate.

Mid tibia rather heavily scaled; hind tibia less so, but tarsi with tuftlike scales.

Genitalia (fig. 4) with harpe simple; anellus broad, deeply incised; gnathos long, slender, distal end a short, sharp, upturned hook; uncus short, broad; aedeagus (fig. 4a) without cornuti.

Alar expanse. — 18 mm.

FEMALE (pl. 1; figs. 3, 5). — Antenna simple. Third segment of labial palpus short, length not more than one-half that of second. Mid and hind tibia similar to those of male, but with scaling of hind tarsi fringe-like instead of tufted. Maculation similar to male.

Genitalia (pl. 1; fig. 3) with a narrow sclerotized band along lower margin of genital opening; a small patch of spines slightly below ductus seminalis; bursa copulatrix weakly scobinate.

Alar expanse. — 20 to 22 mm.

Type and paratypes. — In U. S. National Museum, No. 61425.

Type locality. — Maiz, San Luis Potosi, Mexico.

Food plant. — Orchids (plant roots).

Material. — MEXICO: Maiz, San Luis Potosi (male type and 4 female paratypes); Antiguo Morales, San Luis Potosi (2 male and 2 female paratypes).

EXPLANATION OF PLATE 1

Fig. 1. Female fore and hind wing.

Fig. 2. Male fore and hind wing.

Fig. 3. Female genitalia, ventral view.

Fig. 4. Male genitalia with aedeagus removed, ventral view.

Fig. 5. Female adult.

Drawings by Arthur D. Cushman, scientific illustrator of U. S. Bureau of Entomology and Plant Quarantine.

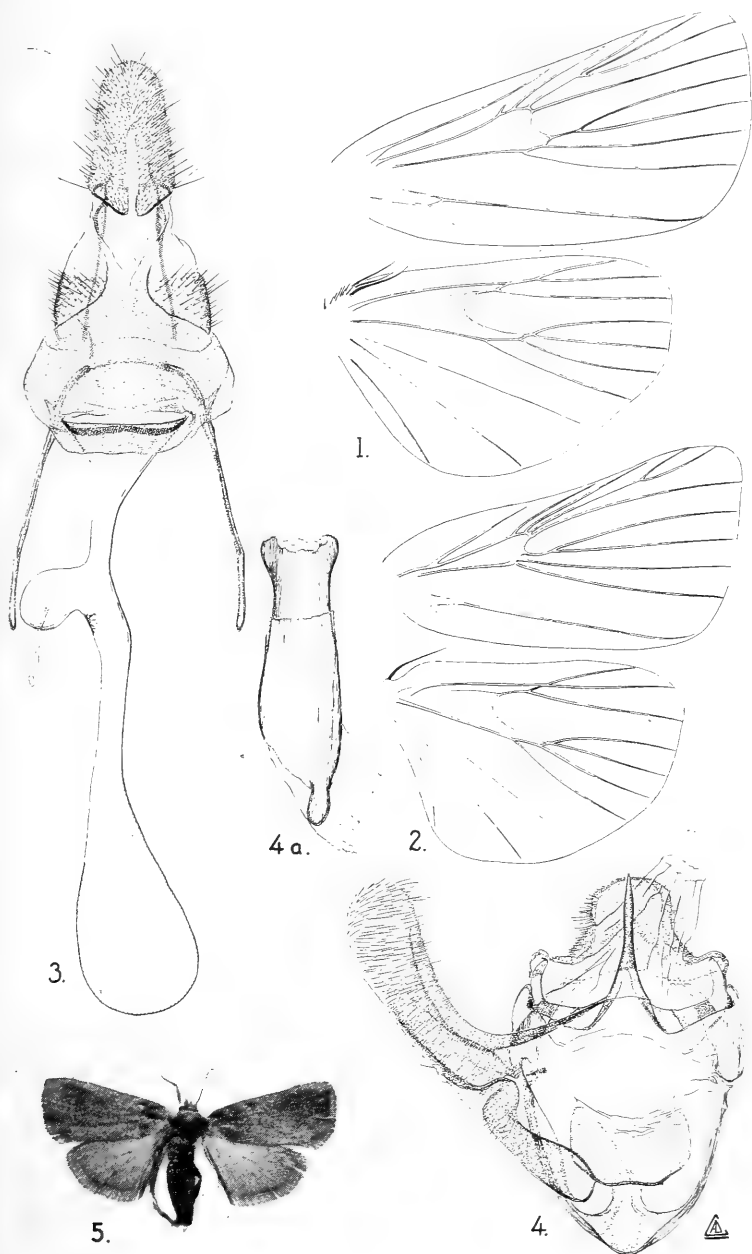


Plate 1

A NEW STREPSIPTEROUS PARASITE OF MEMBRACIDAE

By W. DWIGHT PIERCE

The Strepsiptera are an order of insects seldom seen by the average collector, although they may be present in the very area collected. The females are larviform, and found only in the abdomens of other insects, with only a cephalothoracic disc protruding between the segments; while the males are winged, very erratic in flight, and seldom found.

They parasitize the primitive silver fish, grasshoppers, ants, bees, wasps, bugs, and leaf hoppers in various parts of the world.

As I have elsewhere stated, the Aleurodoptera, Coccoptera, Strepsiptera, and Cyclorrhaphous Diptera form an ordinal group, Pupariata, in which the last larval skin becomes a puparium in which pupation takes place. The head of the puparium becomes a lid, the cephalotheca, in the Strepsiptera and Diptera, which is pushed off on emergence.

The wing venation in the first three orders is very simple, with no cells or cross veins. In the Strepsiptera the most primitive forms have a short basal Costa; a marginal Subcosta; Radius 1 often broken near middle of wing, with one or two fragments of Radial Sector beyond; Media usually free from base and extending to margin, but often broken at middle, with Media 1 always free and anterior to the main stem; sometimes with loose fragments representing Media 2, 3, and 4; Cubitus free, but usually Cubitus 1, if present, does not reach the base; while Cubitus 2, if present, is complete; one, two or three Anal veins.

Although the Strepsiptera have been reported from numerous species of Homoptera of the superfamilies Fulgoroidea and Jassoidea, there is only one published record of parasitism of the Membracidae. Subramaniam in 1927 described *Indoxenos membraciphaga*, bred from *Otinotus pallescens* Distant, in Mysore State, India. This was placed in the Halictophagidae.

It is now my pleasure to describe the first American parasite of the Membracidae. Mr. Cedric R. Jordan, a graduate student at the Texas A. & M. College, is working on the biology and control of the three-cornered alfalfa hopper, *Spissistylus festinus* (Say) (*Stictocephalus f.* Say). He has found this leaf hopper parasitized at Curtis, Louisiana, and College Station, Texas.

The abdomen of this leaf hopper is small, triangular in cross section, and in most cases there is room for only one parasite, but there were four hosts with two visible parasites each, one with males, two with females, and one with a male and a female. But on dissection, the writer found in one host 2 females, and 3 male

puparia; in another a female and a larva. In the material sent for study 21 ♀ and 12 ♂ hoppers were parasitized by 37 visible parasites, or, as stated above, 41 parasites in all. These consisted of 18 ♂, 22 ♀, and one larva. In all but two hosts the parasites protruded from ventral segments; 1 ♀, 1 ♂ in 1st segment; 5 ♀, 4 ♂ in 2nd ventral; 1 ♀, 1 ♂ in 2nd dorsal; 11 ♀, 6 ♂ in 3rd ventral; 1 ♂ in 3rd dorsal; 4 ♀, 2 ♂ in 4th ventral; 3 ♂, 1 larva internal.

Most of the material was collected July 16, August 10, 11, and 28, 1950, at Curtis; and September 25, and 27 at College Station. The one mature male was obtained September 27.

The characters of this insect warrant description of a new genus in the family Halictophagidae. The wings of Halictophagidae all lack Cubitus 1 and some lack Cubitus 2. The species so far described have in no case more than 3 veins in the cubito-anal area. The new species has Cubitus 2 and 3 anal veins.

GENUS MEMBRACIXENOS, new genus.

Halictophagidae, with seven-jointed antennae, the third to seventh flabellately produced and covered with delicate sense organs; special sensory organ at base of flabellum of 4th segment; three-jointed tarsi. Head of male dorsally broadly excavate for pronotum, but ventrally not excavate. Wing (Figure 2), with surface covered by microtrichia; with basal Costa; marginal Subcosta; darkened area between Subcosta and Radius; detached Radial Sector, and detached Media 1; Media 2 complete; Cubitus 1 missing; Cubitus 2 complete; 1st Anal extending only to middle of wing; 2nd Anal and 3rd Anal detached at base. Abdomen beneath (Figure 4) with 7 chitinized sternal plates.

Type — *Membracixenos jordani*, new species.

Membracixenos jordani, new species

(Plate 2; Figures 1-8)

Parasite of the Membracid, *Spissistylus festinus* (Say). Type locality, College Station, Texas; paratype locality Curtis, Louisiana. Described from 1 male (holotype); fragments of another male, and an extracted male in poor condition; 4 male cephalothecae; 11 male puparia; 2 male pupae; 14 females (including allotype); 6 larvae; and many triungulinids; mounted upon 38 microscope slides, with additional material in 8 vials of alcohol.

Male measurements: length 1.94 mm.; breadth of head 0.573 mm.; length of head on center line 0.15 mm.; length of antennae 0.439 mm.; length of thorax 1.146 mm.; hind leg coxa 0.18 mm., femur 0.28 mm., tibia 0.30 mm., each tarsal joint 0.08 mm.; wing lateral expansion width 1.4325 mm., length from costa to apical margin 1.088 mm.; length of abdomen on side 0.955 mm.; oedeagus 0.114 mm.

Head (Plate 2; Figures 1, 6) transverse, laterally stalked, bearing eyes; much broader than thorax; anterior occipital margin slightly concave; genae diagonally retreating to eyes; antennae widely separated by the broader frontal process; dorsal base trapezoidally emarginate for reception of pronotum. Ventrally the unprotected mouth opening is in front of the middle of a subquadrate darkened facial area; at the margins of which are set the short acute mandibles, and two-jointed maxillary palpi. The antennal joints terminate almost on an even line. Hofeneder's special sense organ can be seen indistinctly near the base of the flabellum of the 4th segment.

The pronotum is arched forward to fit into the emargination of the head; posteriorly it is biemarginate; laterally it is a very narrow band to the venter. The intersegmental skin between pronotum and mesonotum is broader than either segment. Mesonotum is a narrow ring band with diagonal pleural strips. The elytra or balancers are about as long as the width of the mesonotum. The metathoacic pattern is quite normal, with key-stone-shaped prescutuin, scuti not in contact, scutellum semi-elliptic; postlumbium transverse; postscutellum rather short, about as wide as long. Tarsi (Figure 3) all 3-segmented; each arising distant from the apex of the preceding.

Although the type male, which was extracted from a puparium, does not show the oedeagus, this is distinct in another male, also extracted, but otherwise not in good condition. These specimens will be kept in alcohol. The terminal segment (Figure 5) is almost vertical, and the oedeagus is a simple twice bent tube, with very sharp apex. It is very much the shape of that of *Pseudoxenos neomexicanus*, but different from all of the described Halictidae.

EXPLANATION OF PLATE 2

Membracixenos jordani Pierce

1. Adult male body, dorsal view. Length 1.9 mm.
2. Wing of male: A—Anal veins; C—Costa; Cu—Cubitus; M—Media; R—Radius; Rs—Radial Sector; Sc—Subcosta.
3. Parts of legs: *a, b*—tarsus of fore leg; *c*—tibia and tarsus of middle leg; *c*—tibia and tarsus of middle leg; *d*—hind leg.
4. Venter of male abdomen.
5. Terminal segment of male, showing oedeagus.
6. Face of male.
7. Cephalotheca of male puparium; *Ant.*—antenna; *as*—antennal suture; *Clp*—clypeus; *E*—eye; *Ephy*—epipharynx; *es*—epistomal suture; *Ge*—gena; *Gn*—gnathocephalon; *hs*—hypostomal suture; *Md*—mandible; *Mth*—mouth; *Mx*—maxilla; *Oc*—occiput; *Of*—occipital foramen; *Pge*—postgena; *Poc*—postocciput; *pos*—postoccipital suture; *Prt*—pariental; *Sg*—subgena; *Smt*—submentum; *Vx*—Vertex.
8. Cephalothorax of female.

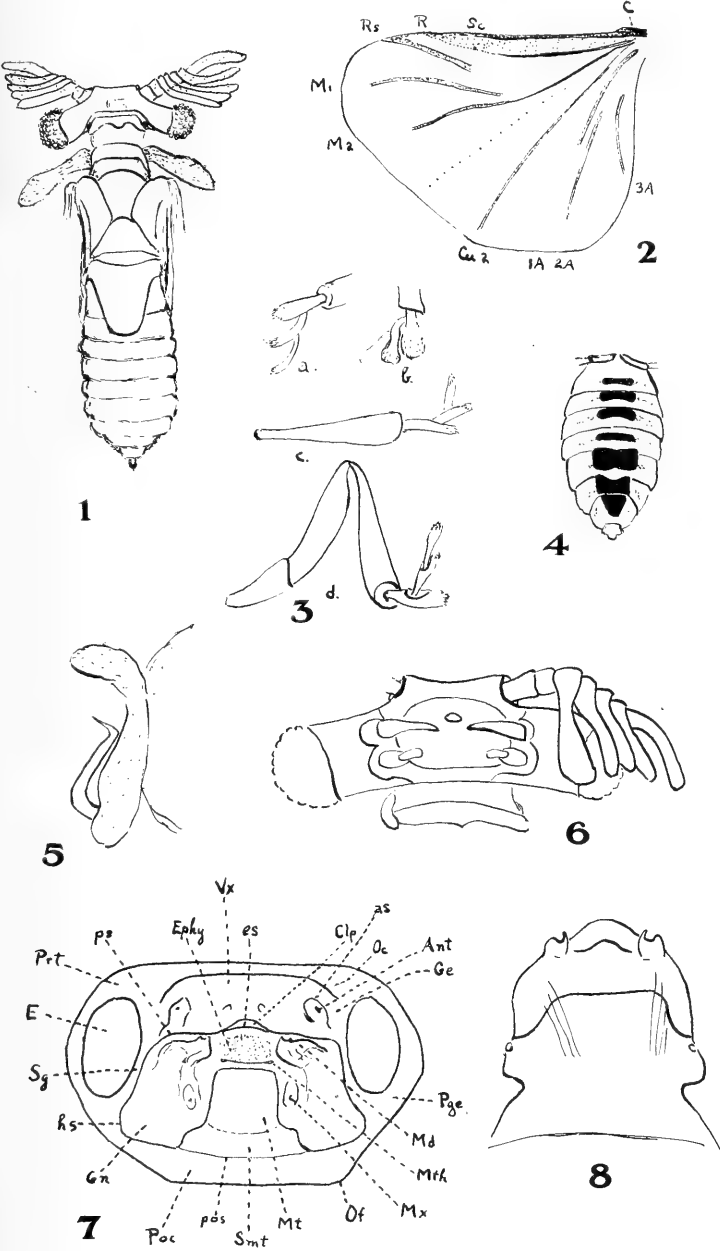


Plate 2

Male cephalotheca (Figure 7): breadth 0.668 mm.; length 0.4202 mm. In form somewhat similar to that of *Diozocera*, but with mentum more quadrate. The areas are designated in Figure 7. The mandibles are 2-toothed.

Female (Plate 2; Figure 8) cephalothorax 0.32 mm. long from apex to constriction behind spiracles; greatest breadth 0.42 mm. The body is a sac, which fits into the available space in the abdomen of the host. The cephalothorax is very different in form from that of *Indoxenos*, which is elongate, but is similar to that of *Diozocera*. The mandibles are armed in the inner apex with a curved tooth, and on the outer apical angle with a rounded tooth. They protrude beyond the anterior margin of the head. The outer angles of the base of the head are immediately in front of the cephalothoracic spiracles, as in *Indoxenos* and *Diozocera*, a character by which they differ very greatly from the Stylopidae.

Triungulinid: average length 0.191 mm.; width 0.0382 to 0.047 mm. wide; thus being as long as those of *Indoxenos*, but very much more slender.



IPHITIME AND CERATOCEPHALA (POLYCHAETOUS ANNELIDS) FROM CALIFORNIA*

By OLGA HARTMAN

Allan Hancock Foundation, University of Southern California

The purpose of this paper is to call attention to the presence of two new marine annelids from California, belonging to two rare genera that have remained unreported, one from the Western Hemisphere, the other from the western part of North America. The first, *Iphitime loxorhynchi*, new species, is a member of the family LYSARETIDAE, superfamily EUNICEA; the second *Ceratocephala crosslandi americana*, new subspecies, belongs to the family NEREIDAE.

I am indebted to Professor and Mrs. George E. MacGinitie, who first called my attention to the presence of annelids within the carapace of the kelp-crab, *Loxorhynchus grandis* Stimpson, and who, with Dr. C. A. G. Wiersma, collected many specimens from Southern California. The late Dr. Shiro Okuda of Hokkaido University, sent me specimens of *Iphitime döderleini* Marenzeller from Japan, for comparison. For the nereids I owe thanks to the cruising staffs of the *E. W. Scripps*, Scripps Institution of Oceanography, and the *Velero IV*, University of Southern California. Anker Petersen, staff artist of the Allan Hancock Foundation, prepared the illustrations for the two plates. I am especially indebted to the Administration of the Allan Hancock Foundation for permitting the study of these materials. Type specimens are deposited in the Allan Hancock Foundation.

LYSARETIDAE Kinberg, 1865

This family is largely tropical in its occurrence. It is known for few (possibly seven or eight) species belonging to four genera: *Lysarete* Kinberg, 1865, *Halla* Costa, 1844, *Aglaurides* Ehlers, 1864-68 and *Iphitime* Marenzeller, 1902. All of the species, except those of *Iphitime*, are free-living and come to attain considerable size; thus, *Halla parthenopeia* (delle Chiaje), an important fish-bait worm in some parts of the world, may come to be 90 cm (about three feet) long (Okuda, 1933, pp. 243-247). *Iphitime* is known only from the branchial chambers of Crustacea, and its representatives do not attain such great size.

Most of the lysaretids are brightly colored in life; they are errantiate in their habitat and foraging or predaceous, attacking lamellibranchs or other organisms by enveloping their victims with mucous secretions. Some, when placed under unfavorable conditions, emit a dark violet secretion (Okuda, 1933, p. 246). The species of *Iphitime* are not highly colored, can be presumed to be nestling in their habitat, and may feed only on the minute particles of food that are carried into the branchial compartments

*Contribution No. 94 of the Allan Hancock Foundation, University of Southern California, Los Angeles, California.

by water currents. Nothing is known of the origin of the worm, of its fate at ecdysis of the crab, or of its means of reproduction. There are no records of *Iphitime* having been taken outside of the crab. Whether the species are host-specific may be doubted, since some records (see below) indicate otherwise.

Another representative of the EUNICEA, *Ophryotrocha geryonicola* (Bidenkap), is also an inhabitant of the branchial chamber of a crab, *Geryon tridens* Kröyer, in western Europe. In this case it has been suggested that the commensal stage is possibly a modified one of the free-living *Ophryotrocha puerilis* (Claparède and Metchnikow) (see Wesenberg-Lund, 1938, p. 13).

There is no known homologous, free-living stage for species of *Iphitime*. The crab-dwelling individuals of this genus cannot thus be considered to represent trapped stages of a free-living form. Furthermore, the entire maxillary apparatus, the parapodial lobes and setae, as well as other body parts are considerably modified from the typical, errantiate lysaretid body.

Iphitime Marenzeller, 1902

Type I. *döderleini* Marenzeller, 1902

Most of the literature on *Iphitime* has been assembled (Fage and Legendre, 1934, pp. 299-305). This includes descriptive accounts of three species. A fourth one is herewith added. These are:

1. *döderleini* Marenzeller, 1902, from south Japan, with host *Macrocheira kaempferi* de Haan.
1. *cucnoti* Fauvel, 1914, from France, with hosts including species of *Portunus*, *Gonoplax*, *Macropodia* and *Maia*.
1. *paguri* Fage and Legendre, 1934, from France, with hosts including brachyuran and anomuran crabs.
1. *loxorhynchi*, new species, from California, with host *Loxorhynchus grandis* Stimpson.

Iphitime is characterized for having a greatly reduced prostomium that lacks eyes. Its frontal margin has a single pair of small ovoid antennae. The first two segments are achaetous, smooth rings. Parapodia occur from the third segment and are entirely uniramous. On the eversible pharynx the maxillary apparatus is greatly reduced. When retracted it can be seen as a small dark mass lying in about the second segment. The maxillae or dorsal pieces consist of a pair of larger forceps, followed by a few smaller pieces in paired tandem, numbering only a single pair, or few more. The mandibles or ventral pieces consist of a pair of medially fused long pieces, with outer lateral wings at the anterior or cutting edge. Parapodia consist of a pair of simple lobes between which the setae project; there are no ventral cirri. Setae include simple and composite ones; all are falcate. Branchiae are segmental and present on most body segments; they are simple or branched.

The chief specific characters are those concerned with the distribution of branchiae, their degree of branching, the position of the branchial base on the parapodium, and the details concerning the setae.

***Iphitime loxorhynchi*, new species**

Plate 3, figs. 1-6

Many individuals come from off Corona del Mar and other localities in southern California, from the branchial chambers of the sheep-crab or kelp-crab, *Loxorhynchus grandis* Stimpson. Length of a larger, ovigerous female individual is 60 to 70 mm; number of segments is 200 or more. This is thus the largest of the known species of the genus (see chart below for details). The prostomium is a small, subquadrate lobe provided with a pair of minute antennae at the anterior margin (fig. 1); there are no eyes or other accessory parts. The proboscis, seen by dissection, is provided with mandibles fused medially at its distal part; their outer margins are enlarged as a pair of thin lateral plates (fig. 6) the dorsal maxillae include a pair of large forceps and smaller distal pieces, the right one with four or five short teeth, the left one smooth (fig. 6).

Branchiae are first present from the second setigerous segment and already long but the next are half again as long. In most instances the branchiae are simple, cylindrical processes (figs. 2, 3); in others they are somewhat branched, especially in their distal parts (fig. 1). The main branchial stem is directed obliquely outward. Its origin is somewhat above the superior parapodial base.

Parapodia are lateral, consist of a dorsally directed upper lobe (figs. 2, 3); the setae project from between their anterior and posterior lobes. Posterior (fig. 3) resemble median (fig. 2) parapodia except for decreasing size. All acicula and setae are pale yellow. Typically the parapodia have 20 or more simple hooks (fig. 4) above, about 6 similar ones below the acicula and 20 or more composite hooks. Acicula number about 6 or more in a parapodium; each is a slender, tapering rod. The composite hooks (fig. 5) have an appendage that is falcate. Simple setae (fig. 4) resemble the composite hooks but have no articulation.

In mature specimens there are lozenge-shaped ova, present from about the seventeenth setigerous segment and continued back to near the posterior end. The ova are very numerous and crowded, such that they are pushed upward into the branchial bases for about half the branchial length.

There is no color remaining in preserved individuals. In life they may be pale red or pink, owing to the color of the blood. There are few to many, possibly ten or more individuals from single crab hosts, and worms are sometimes present in both branchial chambers.

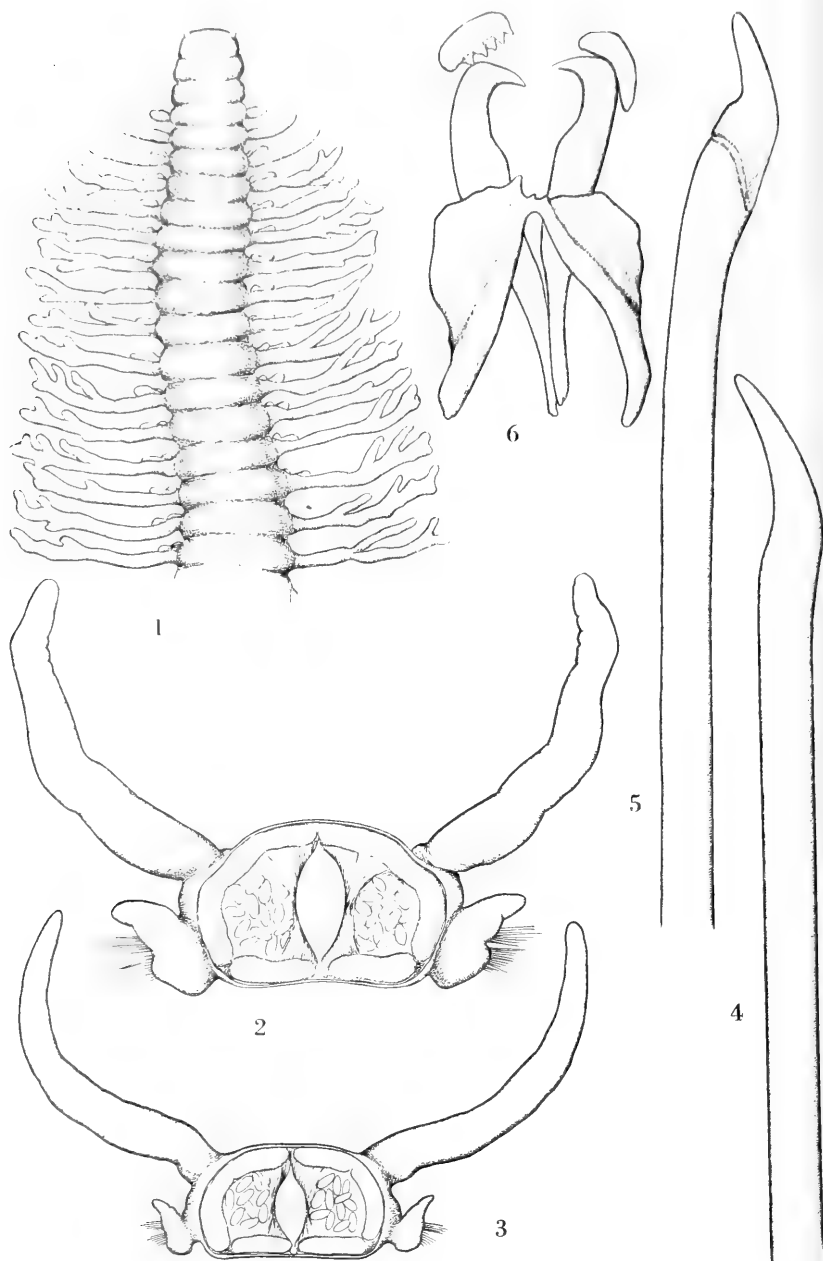


Plate 3

The specific name of the worm refers to the generic name of the host, *Loxorhynchus grandis*, Stimpson, which has a reported range (Rathbun, 1925, pp. 198-199) of central California to Baja California, Mexico, in depths to 68 fms. This represents the first record of the genus *Iphitime* Marenzeller from the Western Hemisphere. The following chart outlines the chief characteristics for species of the genus, and gives distributional data with host species.

NEREIDAE Blainville, 1818

In members of the family NEREIDAE the eversible proboscis is a strong, muscular organ differentiated into an oral and maxillary ring; it terminates distally in a pair of horny jaw pieces. The areas on the maxillary ring are numbered from I to IV, those on the oral ring V to VIII; typically the areas are provided with structures generically and specifically differentiated. In the great majority the pieces are horny brown or black, called paragnaths (*Nereis* and *Neanthes*), or pectinae (*Platynereis*), or ridges (*Perinereis*). In one group, *Leonnates* Kinberg, the pieces are horny on the maxillary, and soft and membranous on the oral ring. In comparatively few genera the processes are totally lacking; such are the genera *Dendronereis* Peters, *Kainonereis* Chamberlin, *Leptonereis* Kinberg, *Lycastoides* Johnson, *Lycastopsis* Augener, *Micronereis* Claparède, *Namanereis* Chamberlin and *Nicon* Kinberg. In a still smaller group of species the processes on the proboscis are present as soft, membranous, short to long papillar structures; they may be present on both oral and maxillary rings, as in the genera *Chinonereis* Chamberlin, *Dendronereides* Southern, *Laeonereis* Hartman, *Tylonereis* Fauvel and *Tylorrhynchus* Grube, or they may be present on only the oral ring, as in *Ceratocephala* Malmgren.

At present, the genera characterized for the presence of soft, membranous proboscicial processes, are rather weakly differentiated and generally little known. Most of these genera have single or few species attributed to them. Many of them are inhabitants of brackish or freshwater and widely dispersed geographically. At least two, those of *Tylorrhynchus* and *Chinonereis*, are pests in rice paddies, in eastern and southern Asia; *Dendronereides* is known for a single freshwater species from India; *Tylonereis* is known for only two species, both from southern Asia, and

EXPLANATION OF PLATE 3

Iphitime loxorhynchi, new species

Fig. 1. Anterior end in dorsal view, x 8.5.

Fig. 2. Median parapodium in posterior view, x 16.

Fig. 3. Posterior parapodium in posterview view, x 16.

Fig. 4. A superior simple hook, x 1068.

Fig. 5. An inferior composite hook, x 1068.

Fig. 6. Paragnathal apparatus, with mandibles and maxillae in ventral view, x 146.

Chart for Species of *Iphitime* with diagnostic characteristics and distributional data

Name of Species	Total length in mm.	Host Species and locality	Number of setigerous segments	First presence of Branchiae, and character	Parapodial Components
<i>I. loxorhynchi</i> Hartman	60-70	<i>Loxorhynchus grandis</i> Southern California	200 or more	Second; simple to divided, inserted laterally	About 20 simple supra-acicular, 20 composite hooks, 6 simple sub-acicular hooks and about 6 acicula
<i>I. döderleini</i> Marenzeller	61	<i>Macrocheira kaempferi</i> Japan	185 to 210	First; simple and palmate from 9th, with to 9 lobes, inserted midlaterally	Many composite hooks, 10 large and 4-5 small, simple hooks, and about 4 acicula
<i>I. cuenoti</i> Fauvel	7-12	<i>Maia squinado</i> <i>Portunus</i> spp. <i>Gonoplax angulata</i> <i>Macropodia longirostris</i> All from Europe	20-60	First; digitiform to divided, inserted laterally	About 20 composite hooks and 4 or 5 simple hooks.
<i>I. paguri</i> Fage & Legendre	7	<i>Gonoplax angulata</i> <i>Macropodia longirostris</i> <i>Portunus depurator</i> <i>Eupagurus bernhardus</i> All from Europe	86-90	Fourth; digitiform, inserted dorsally	7 or 8 composite hooks and one simple hook.

Laeonereis is known for perhaps half a dozen species from widely scattered localities. *Ceratocephala* is known for few species (see chart below) and all are marine though in widely scattered geographic areas.

Key to Genera of NEREIDAE in which the Proboscoidal

Processes are soft and membranous

- | | |
|---|-----------------------|
| 1. Pharyngeal processes limited to the oral ring
(pl. 2, fig. 1)..... | <i>Ceratocephala</i> |
| 1. Pharyngeal processes present on both oral
maxillary rings | 2 |
| 2. Parapodia with branchiae in the form of fila-
ments inserted below the dorsal cirrus..... | <i>Dendronereides</i> |
| 2. Parapodia without branchiae..... | 3 |
| 3. Proboscis provided with tufts of papillae..... | <i>Laeonereis</i> |
| 3. These papillae single, not in tufts..... | 4 |
| 4. Setae include spinigers and falcigers..... | <i>Tylorrhynchus</i> |
| 4. Setae are entirely spinigers..... | 5 |
| 5. Setae have an articulation that is heterogomph | <i>Chinonereis</i> |
| 5. Setae have an articulation that is homogomph | <i>Tylonereis</i> |

Ceratocephala Malmgren, 1867

Type *C. loveni* Malmgren

This genus is characterized for having a prostomium that is proportionately wide; its frontal margin is incised between the bases of the paired antennae; the palpi are spreading, and prostomial eyes are reduced or absent. The eversible proboscis has distal jaws that lack teeth. The maxillary ring is bare; the oral ring has a few soft, conical processes in single, or partially double, transverse rows. The first two parapodia are uniramous, more posterior ones are biramous. Ventral cirri (usually) are double in some or all segments. Setae are entirely composite spinigers, with an appendage that is blade-like and with few or no spinelets along the cutting edge.

The few known species are distinguished from one another for the presence or absence of eyes, the character of the dorsal cirrophore, and the proportionate lengths of parapodial lobes. Since most of the species are known only from anterior, dredged ends, a comparison of far posterior parapodia is not possible. The occurrence of epitoky is known for at least one species, from the Dutch East Indies.

The following species are known:

- C. loveni* Malmgren, 1867, from western Sweden and northeastern America, dredged from moderate depths.
- C. sibogae* Horst, 1924, off the Dutch East Indies, 11 m to surface, and more recently recorded from Littoral sands of South America (Fauvel, 1936, pp. 24-28).
- C. crosslandi* (Monro), 1933, from Gorgona Island, Pacific Panama, 30 fms.

C. borealis Wessenberg-Lund, 1950, from western Greenland, 599 and 1096 m.

Another, close to *C. crosslandi* Monro, has recently been recovered from southern California; it is herewith described as subspecies *americana*, new.

Key to Species of *Ceratocephala* Malmgren

- | | |
|---|--------------------------------|
| 1. Prostomium without eyes | 2 |
| 1. Prostomium with 4 eyes in quadrate arrangement | 3 |
| 2. Proboscis with 2 rows of soft papillae on areas VII-VIII | <i>C. loveni</i> |
| 2. Proboscis with a single row of papillae on areas VII-VIII | <i>C. borealis</i> |
| 3. Dorsal cirrophore with a large triangular lobe lateral to base of dorsal cirrus..... | <i>C. sibogae</i> |
| 3. Dorsal cirrophore without a triangular lobe lateral to base of dorsal cirrus..... | 4 |
| 4. Dorsal cirrus of first 2 segments simple; ventral cirrus double throughout..... | <i>C. crosslandi</i> |
| 4. Dorsal cirrus of first 2 segments double; ventral cirrus becoming simple at about segment 35 | <i>C. crosslandi americana</i> |

Ceratocephala crosslandi americana, new subspecies

Plate 4, figs. 1-3)

Chaunorhynchus crosslandi Monro, 1933, pp. 46-49, figs. 20 a-f (stem species).

There are two finds, the larger one comes from off Lower California, Mexico, 29° 34' 15" N., 115° 48' W, in 53-54 fms, April 15, 1951, green mud; the other was dredged off La Jolla, California, in less than 50 fms, April, 1938. Both are anterior ends; the larger has the proboscis everted, the other has it retracted.

The larger measures 19 mm long for 16 segments and 2 mm wide without parapodia; the smaller one measures 19 mm long for 40 segments and is about 1 mm wide. On the everted proboscis the distal paired jaws are translucent dark horny brown; the cutting edge is entire. The maxillary ring is smooth; the oral ring has transversely arranged conical processes. Areas V and VI have one each (fig. 1). Areas VII and VIII are continuous, with a single row of 7 soft cones; in addition there is a pair of transverse short ridges on each side, toward the mouth and at the lateral edges of the oral papillae (fig. 2.).

The prostomium is wider than long; it has a pair of large frontal antennae widely separated medially. The palpi are only slightly larger than the antennae. There are 4 dark eyes in trape-

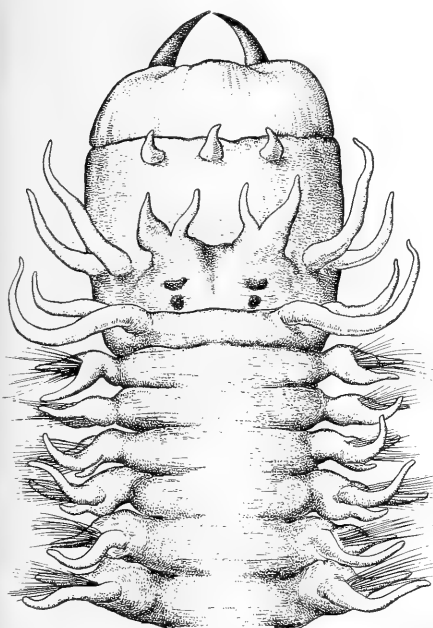
EXPLANATION OF PLATE 4

Ceratocephala crosslandi americana, new subspecies

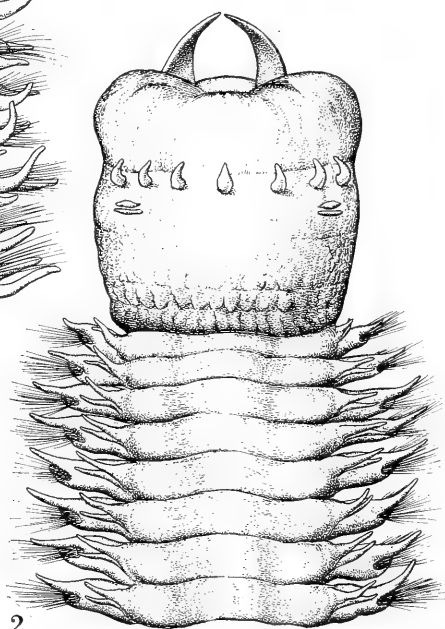
Fig. 1. Anterior end in dorsal view, with proboscis everted, x 14.5.

Fig. 2. Anterior end in ventral view, with proboscis everted, x 14.5.

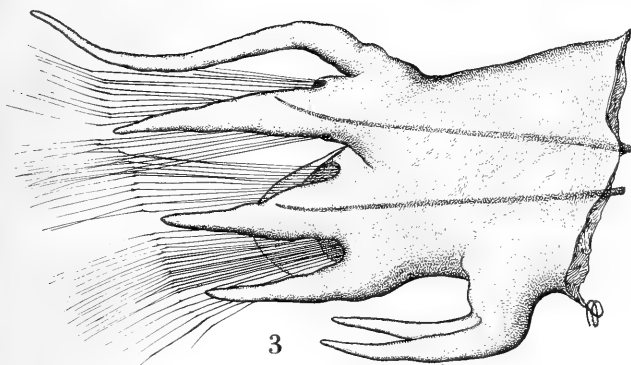
Fig. 3. Fourteenth parapodium in anterior view, x 42.5.



1



2



3

Plate 4

zoidal arrangement; the anterior are larger and wider apart than the posterior eyes. All have large, pale, circular lenses that cover most of the distal disk, when seen from above. The 4 pairs of peristomial cirri have the proportions shown in figures 1 and 2. The first visible body ring lacks parapodia. The next 2 segments have uniramous parapodia and thereafter the parapodia are clearly biramous.

The dorsal cirrus of the first two segments is unique for being double; it consists of a main dorsal branch; from its lower base there arises a secondary cirrus that is about half as large as the main one; this accessory dorsal cirrus is the same on both first and second segments of both specimens, hence probably normal. Thereafter, through a few segments, this accessory cirrus is visible as a slight boss at the base of the main dorsal cirrus and gradually vanishes.

Biramous parapodia are long, directed laterally and resemble those in other species of the genus. The dorsal cirrus is long, slender, distally tapering; in anterior segments it seems to arise directly from the body wall. In more posterior segments the cirrophore is visible as a low base, and by segment 35-40 it comes to be about as large as its respective notoacicular lobe. The presetal acicular lobe is long, slender, triangular and resembles the corresponding neuropodial one but is longer. The postsetal lobes of both notopodia and neuropodia are broadly rounded, short, the neuropodial surpassing the notopodial one in length and depth (fig. 3). A similarly long inferior lobe is present at the inferior, anterior position of the parapodium. The proportions of these parts vary little through the first 35 to 40 segments.

The ventral cirrus is double from the first parapodium; its upper branch is slightly longer and broader than the lower one. Farther back it continues double but the lower branch decreases in size so that by segment 21 the lower branch is only about half as long as the upper one. Between segments 30 to 40 the lower one vanishes altogether as a low knob, at the lower proximal base of the main cirrus. It is possible that the ventral cirrus may be single in the posterior region of the body.

Acicula are dark, slender, distally tapering; they occur singly in the branches of the parapodia. Setae are entirely composite, spinigerous, with the appendage long and slender, and with the cutting edge nearly or quite smooth. Setae are in dense fascicles in anterior parapodia and diminish in number in middle segments.

The subspecies, *americana*, differs from the stem, *C. crosslandi* in that the dorsal cirrus of the first two segments is double, not single; the ventral cirrus of median segments comes to be single, and does not continue as a double process. Other differences are indicated on the chart, below.

The following chart outlines the chief features of the species of the genus *Ceratocephala*, with known distributional data.

Chart for Species of *Ceratocephala*, with diagnostic characteristics and distributional data

Name of Species	Locality	Processes on Proboscis	Character of ventral cirri	Prostomial eyes	Character of dorsal cirrophore in anterior segments
<i>C. loveni</i> Malmgren	Northwest Europe, Eastern Canada, New England; depths to 100 fms.	V and VI with one each, VII and VIII a continuous row of about 7 and a second row of about 3	Double throughout	Absent	Undeveloped
<i>C. sibogae</i> Horst	Off Dutch East Indies, 11 m. to surface	V with 2 papillae, no others present	Simple throughout	4; anterior smaller than posterior ones	A long, triangular lobe at base of dorsal cirrus
<i>C. sibogae</i> sensu Fauvel	Southern South America, in littoral sands	V and VI with 3 in a row; VII and VIII with 7 in a row	Double throughout	4 present	A long, triangular lobe at base of dorsal cirrus
<i>C. crosslandi</i> (Monro)	Gorgona Island, Panama, 30 fms.	V and VI with 3 in a row; VII and VIII with a single row of about 8 papillae	Double through 38 segments, not known thereafter	4 present	Undeveloped
<i>C. crosslandi</i> <i>americana</i>	Southern and Lower California, 54 fms. or less	V and VI with 3 in a row; VII and VIII with a row of 7, and 2 short ridges on each side	Double through anterior segments, becoming single at about segment 35	4 present; anterior larger and wider apart than posterior pair	Undeveloped
<i>C. borealis</i> Wesenberg-Lund	Western Greenland, 599 and 1096 m.	V and VI with 3 in a row; VII and VIII with 7 in a single row	Double throughout, insofar as known	Absent	Undeveloped

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DR. JOHN HERMAN
1878 - 1951

In the passing of Dr. John Herman on October 8, 1951, the Southern California Academy of Sciences has lost a member who labored long and effectively in the interests of science.

Dr. Herman was a member of the Board of Trustees, a Fellow, and a Life Member of the Academy. He was one of the members of the Committee of the Founders Society, which labored incessantly to maintain the status of science in the Los Angeles Museum at a period of time not long past when the future of that division seemed to be seriously threatened.

Dr. Herman was born in Wilmer, Nebraska, June 7, 1878, the son of John and Mary Herman. He received the B.S. degree from the University of Nebraska in 1900, and in 1934 won his D.Sc. from Charles University, Prague, Czecho-Slovakia.

He served as assayer for the Copper King, Canon City, Colorado, from 1900 to 1902, and thereafter was employed by mining and smelting interests in Arizona until he opened his own office in Los Angeles, in 1907, as an assayer chemist and metallurgical engineer. In 1948 he sold his business to the Smith-Emory Company.

Dr. Herman had fifteen or more inventions to his credit, including the Herman screen ball machine. He was V. President of the Mining Association of the Southwest, and held offices or memberships in several societies of a like nature.

He was particularly active in the Dana Society, of which he was a charter member and past President.

As general manager of the Western Mineralogical Exposition, from 1941 to 1948, he did much to popularize the subject of mineralogy.

Dr. Herman married, December 16, 1916, Irene Sparks of Los Angeles, who survives him.

HOMER P. KING AND J. A. COMSTOCK.

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THE LOWER CAMBRIAN OLENELLIDAE OF THE
SOUTHERN MARBLE MOUNTAINS, CALIFORNIA

By JOSEPH F. RICCIO

University of Southern California

ABSTRACT

All morphological entities of the cephalon and thorax of the species studied herein indicate that the Olenellidae was probably a highly specialized family of trilobites. Loss of cephalic spines by resorption in which one pair may remain as the genal spines or two pairs remain as the genal and intergenal spines, is evident in specimens of the Olenellidae. The anterior course of the facial suture, even though fused, indicates that this family belongs to the order Opisthoparia. The hypostoma of *Olenellus* and *Paedeumias*, although distinct from each other, are of generic and not of specific value. Intergenal spines which occur in *O. bristolensis* and *O. insolens* are of generic importance even though they are aborted in early ontogenetic stages. In *O. bristolensis*, the size of the genal angle, position of the genal spines, and the glabellar ratio vary independently of each other whereas the size of the cephalon displays an orderly progression of growth. Trilobites studied herein do not molt in coordinate stages but molt in an orderly progression regardless of the size of the individual.

INTRODUCTION

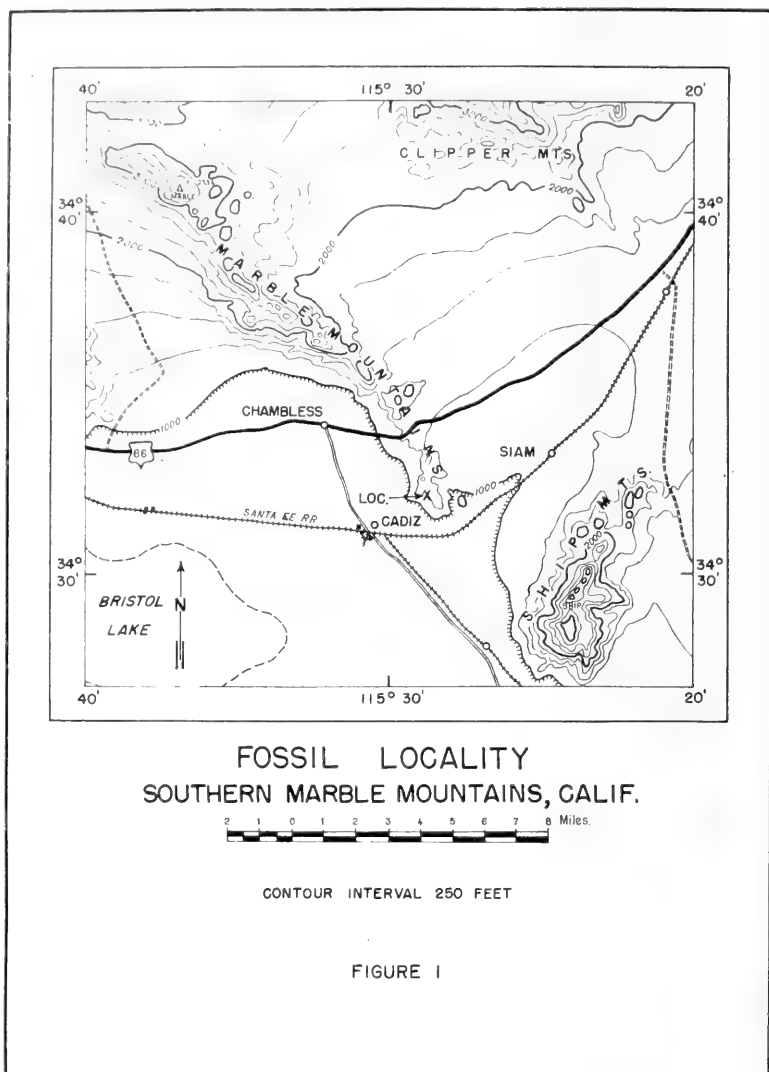
This study is largely concerned with the morphology of the Olenellidae, a family of trilobites, based on their occurrence in the Lower Cambrian strata of the southern Marble Mountains, California. Aside from the morphology, these fossils are important in that they constitute the most southwesterly known occurrence of fossiliferous Cambrian beds in the United States.

The fossil locality is near Cadiz, California, in the eastern Mojave Desert. Cadiz is in the Bengal Quadrangle, on the main line of the Santa Fe Railroad at its junction with the Phoenix branch through Parker, Arizona (fig. 1). A sand trail passable by automobile leads directly to a limestone quarry from the first bend in the graded road approximately $\frac{1}{2}$ mile east of Cadiz. The locality proper is situated 200 yards west of the quarry at the end of an abandoned trail.

Major purposes of this study are:

1. To show the development and subsequent loss of various spines as exemplified by progressive molt stages.
2. To demonstrate the course of the facial suture.
3. To show variations in certain species of *Olenellus*.
4. To determine possible molt stages of the species of *Olenellus* and *Paedeumias*.

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Text Figure 1

ACKNOWLEDGMENTS

The writer is indebted to Dr. W. H. Easton for his guidance on this study of the Lower Cambrian Olenellidae and to the University of Southern California for the use of its facilities. It is gratifying to acknowledge the criticisms and suggestions of Drs. O. L. Bandy, T. Clements, and K. O. Emery.

GENERAL STRATIGRAPHY

Three lithologic units are recognizable in the rocks assigned to the Lower Cambrian in the southern Marble Mountains. The lowermost member, a well-cemented, quartzitic sandstone, rests nonconformably upon granite of Pre-Cambrian age. The sandstone is white to reddish-brown, coarse-grained, commonly cross-bedded, and ranges from 390 to 450 feet in thickness. No fossils were found within this member, although vague impressions which are loosely termed "fucoids" occur in a few places.

The quartzitic sandstone grades upward through a thin transitional zone into a greenish-gray fossiliferous shale which ranges in thickness from 30 to 50 feet. It weathers to paper thin flakes of grayish to reddish color, whereas the fresh shale breaks into platy fragments $\frac{1}{4}$ to $\frac{1}{2}$ inch thick. Intercalated in the shale are reddish-brown quartzose sandstones varying from two inches to one foot in thickness and from ten to twenty-two feet in length. It is from the shale member that the fossils were obtained. Associated with numerous cephalons and pleurons of trilobites are slickensided surfaces resembling cone-in-cone. These may be caused by compaction around the fossil fragments during deposition of the mud. Several of these structures, however, are not associated with the fragments.

Lying conformably on the shale is a gray massive limestone ranging from 80 to 120 feet in thickness. Ovoid algal nodules comprise the greater portion of the limestone.

The three members strike N50W and dip approximately 15 degrees east. Local step-faulting causes changes in dip within short distances.

MATERIALS USED FOR STUDY

Approximately 650 specifically identifiable specimens (Table I) and 500 non-identifiable fragments were used in this study. The specimens of trilobites, with only the best being considered, were tentatively sorted into species and identified from the literature. Specimens of each species were arranged in linear series from smallest to largest. These series were studied carefully to see if any changes took place in the presumed ontogeny shown by adjacent molts.

COMPOSITION OF THE FAUNA

All the trilobites studied herein belong to the family Olenellidae, namely, *Olenellus* and *Paedeumias*. Associated with the olenellids are two genera of brachiopods, *Micromitra* and *Paterina*, trails referable to *Climactichnites*, and a sponge-like impression.

TABLE I
NUMBER OF SPECIMENS OBTAINED FROM THE SHALE MEMBER

<i>Species</i>	<i>No. of Specimens</i>
<i>O. bristolensis</i> (Resser)	114
<i>O. fremonti</i> Walcott	126
<i>O. insolens</i> (Resser)	161
<i>P. clarki</i> Resser	124
<i>P. mohavensis</i> Crickmay	7
<i>P. nevadensis</i> (Walcott)	113

Complete specimens, cephalons, and fragments obtained display the dorsal configuration regardless of whether the specimens are casts or molds. No ventral morphologic surfaces were noted. This lack of ventral surfaces may be due to the peculiar way of molting the animal had in that only the dorsal surfaces would be molted. Or possibly their absence may be explained in that the composition of the ventral portion of the body was such as not to be preserved. Carapaces of trilobites and the preserved shells of the associated brachiopods at this locality are invariably composed of chitin. The test of any organism composed of carbonate would presumably go into solution if the pH of the sea were under seven. Possibly the ventral surfaces of the trilobites contained the carbonate salts and if so, they would not be found fossilized.

The majority of the specimens displays a reddish color which is possibly due to the animals' natural appearance, but is more probably assignable to the presence of ferric compounds within the shale.

The size of the specimens across the cephalic diameter ranges from 1.5 to 96 mm; the greatest size being in *O. fremonti*. Cephalons are extremely thin as compared to those of other trilobites. One specimen which is 2 mm thick can be explained by thickening within the substance of the cephalon proper after entombment by a secondary filling of limonite.

Disassociation of the trilobite segments indicates that the fauna has been transported some indefinite distance to the present site. Inasmuch as the thoracic segments of Lower Cambrian trilobites do not have a good interlocking device but butt up against one another, any motion of the water would tend to disassociate the segments. A large number of fragments have been deposited in conjunction with the coarser sediments and now occur along bedding planes in the lower portion of the quartzose stringers.

The thinness of individual beds, coarseness, and excellent sorting of the sand grains in the stringers, coupled with the fact that the zone of stringers can be traced for miles without discovering a large contemporaneous sandstone body or even appreciable increase in number of stringers indicates that at least that portion of the fauna associated with the sandstone stringers was washed into its present site before entombment. Because the shale contains small amounts of sand grains and doesn't grade into the sandstone stringers, it may represent swirling muds, possibly eddy deposition on the floor of a bay, in which trilobite carapaces were washed to and fro. Thus, the carapaces in the shale may or may not have been transported considerable linear distances. Inasmuch as the specimens do not display ventral skeletons, the lack may be due to decomposition during considerable transportation of the fauna. It would seem, however, that at least a few of the specimens should be entombed with the ventral skeletal side preserved regardless of the distance transported.

CORRELATION

The character of the sedimentary rocks and of the contained fauna indicates that the Lower Cambrian members may be correlated with those described by Darton in the Providence Range to the north and also with those of the Highland Range in Nevada (Clark, 1921, p. 2). According to Walcott (1891, p. 319), *Olenellus* is found in a thin shale bed lying above a massive quartz sandstone in the Eureka district of Nevada and in the Big Cottonwood section of Utah. The same shale bed was carefully sampled one mile north of the collecting area but only a meager fauna consisting of two species of *Paedeumias* was encountered.

SYSTEMATICS

All specimens are deposited in the paleontological collection of the University of Southern California.

PHYLUM ARTHROPODA

CLASS CRUSTACEA

SUBCLASS TRILOBITA

ORDER OPISTHOPARIA

Family Olenellidae Vogdes, 1893

Mesonacis is a junior synonym of *Olenellus* and the family therefore becomes Olenellidae. Although the family has been ascribed to Moberg, Vogdes proposed Olenellidae six years prior to Moberg's identical proposal.

Genus *Olenellus* Hall, 1862

1938. *Olenellus*. Resser and Howell, Bull. Geol. Soc. America, vol. 49, p. 217 (contains prior synonymy).

Genotype. — *Olenellus thompsoni* Hall, 1862.

Resser and Howell (1938), p. 217) have shown that generic differences do not exist between *Olenellus* and *Mesonacis*. The presence of rudimentary or post-thoracic segments which Walcott (1885, p. 328) used to distinguish *Mesonacis* from *Olenellus* is

considered by Resser and Howell not to be of generic importance.

Inasmuch as the writer can only demonstrate the existence of post-thoracic segments on four specimens of *O. insolens* and not in other complete specimens of *O. insolens*, *O. fremonti*, and *O. bristolensis*, it is unlikely that these segments as treated by Walcott are of generic importance (Pl. 6, fig. 1-3). Moreover, no generic differences can be distinguished between the specimens studied and "*Mesonacis*" with regard to the cephalon and thorax. Consequently, the writer is in accord with the disposition of the names "*Mesonacis*" and Mesonacidae as stated by Resser and Howell.

Olenellus bristolensis (Resser), 1928

Plate 7, figures 1, 2, 5; Plate 8, figures 1-11

1928. *Mesonacis bristolensis* Resser, Smithsonian Misc. Coll., vol. 81, no. 2, p. 7, pl. 2, figs. 6-8.

This species displays wide variability in shape of the cephalon. However, the advanced position of the genal spines distinguishes the species. Intergenal spines are present in young molts at the latero-posterior rim of the cephalon. A median node is present on the dorsal surface of the occipital ring.

Olenellus fremonti Walcott, 1910

Plate 7, figure 6

1910. *Olenellus fremonti* Walcott, Smithsonian Misc. Coll., vol. 53, no. 6, p. 320, pl. 37, figs. 1-2.
1928. *Mesonacis fremonti*. Resser, Smithsonian Misc. Coll., vol. 81, no. 2, p. 6, pl. 1, figs. 3-9.

The macropleural development of the third thoracic segment is pronounced but not as much as in *O. insolens*. No post-thoracic segments were noted in any of the specimens. Majority of the specimens representing this species are cephalons.

Olenellus insolens (Resser), 1928

Plate 5, figures 1-13; Plate 6, figures 1-3

1928. *Mesonacis insolens* Resser, Smithsonian Misc. Coll., vol. 81, no. 2, p. 8, pl. 2, figs. 1-4.

This species is characterized by the extremely advanced position of its genal spines; there being no variability in the point of origin of these spines. A median node is present on the dorsal surface of the occipital ring in some specimens. Intergenal spines are present at the latero-posterior edge of the rim in young molts. Four specimens display post-thoracic segments.

Genus *Paedeumias* Walcott, 1910

1910. *Paedeumias* Walcott, Smithsonian Misc. Coll., vol. 53, no. 6, p. 304.
1928. *Paedumias* [sic] Resser, Smithsonian Misc. Coll., vol. 81, no. 2, p. 5.

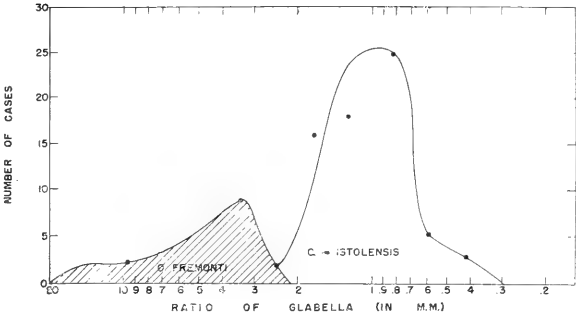


FIGURE 2
GLABELLAR RATIOS OF *O. fremonti* AND *O. Bristolensis*
THE HIGHS IN THE CURVE REPRESENT TWO DISTINCT SPECIES.

Text Figure 2

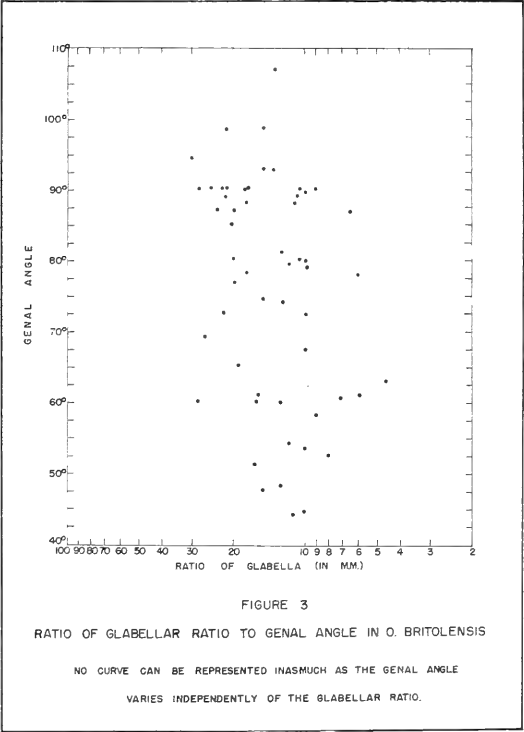


FIGURE 3
RATIO OF GLABELLAR RATIO TO GENAL ANGLE IN *O. Bristolensis*
NO CURVE CAN BE REPRESENTED INASMUCH AS THE GENAL ANGLE
VARIES INDEPENDENTLY OF THE GLABELLAR RATIO.

Text Figure 3

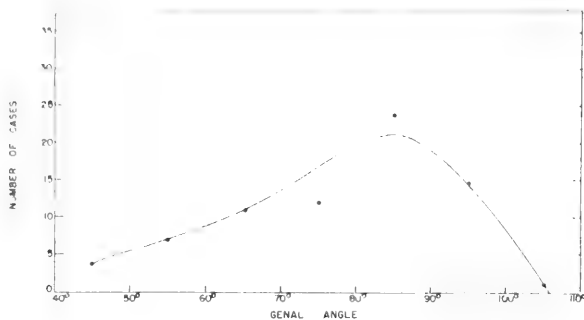
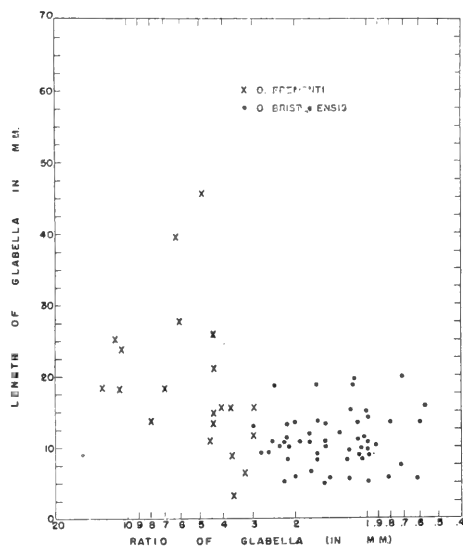


FIGURE 4

GENAL ANGLE OF *O. BRISTOLENSIS*

THE MAJORITY OF THE SPECIMENS HAVE GENAL ANGLES OF 80 TO 90 DEGREES.
FEWER FORMS HAVE AN ANGLE GREATER THAN 90 DEGREES THAN HAVE GENAL
ANGLES FROM 44 TO 80 DEGREES.

Text Figure 4



RATIO OF GLABELLAR RATIO TO LENGTH OF
GLABELLA OF *O. FREMONTI* AND *O. BRISTOLENSIS*

TWO SPECIES ARE SEPARATED ON BASIS OF THE
GLABELLAR RATIO.

FIGURE 5

Text Figure 5

Genotype. — *Paedeumias transitans* Walcott, 1910.

Paedeumias differs little from *Olenellus* except in the position of the glabella, shape of the hypostoma, and by a median ridge that crosses the intervening space between the glabella and the rim. Intergenal spines are present in all species of this genus. The writer did not find any specimen with post-thoracic segments.

Paedeumias clarki Resser, 1928

Plate 9, figures 1-4

1928. *Paedeumias clarki* Resser, Smithsonian Misc. Coll., vol. 81, no. 2, p. 9, pl. 3, figs. 1-2.

P. clarki is distinguished from *P. nevadensis* by the shorter intervening distance between the glabella and the rim and by the fuller anterior lobe of the glabella.

Paedeumias mohavensis Crickmay, 1933

Plate 9, figures 7-8

1933. *Paedeumias mohavensis* Crickmay, California Univ., Dept. Geol. Sci., Bull., vol. 23, no. 2, p. 74, pl. 1, figs. c-f.

This species occurs rarely; only seven small molts were found. It is unlike any other species of *Paedeumias* in that the glabella resembles an hour glass instead of having a tapering shape. The median ridge between the glabella and rim is extremely small or inconspicuous. No complete specimen is known of this species.

Paedeumias nevadensis (Walcott), 1928

Plate 9, figures 5-6

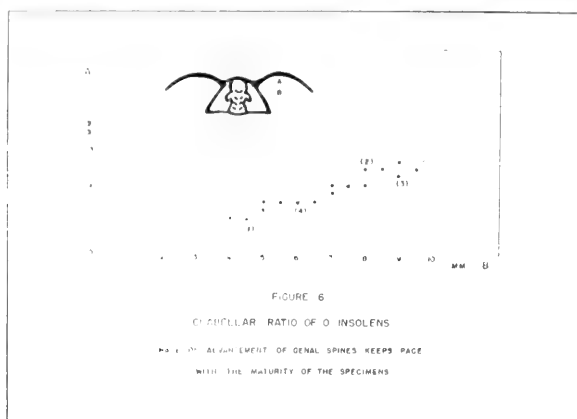
1910. *Callavia* ? *nevadensis* Walcott, Smithsonian Misc. Coll., vol. 53, no. 6, p. 285, pl. 38, fig. 12.

1928. *Paedumias* [sic] *nevadensis*. Resser, Smithsonian Misc. Coll., vol. 81, no. 2, p. 9, pl. 3, figs. 3-7.

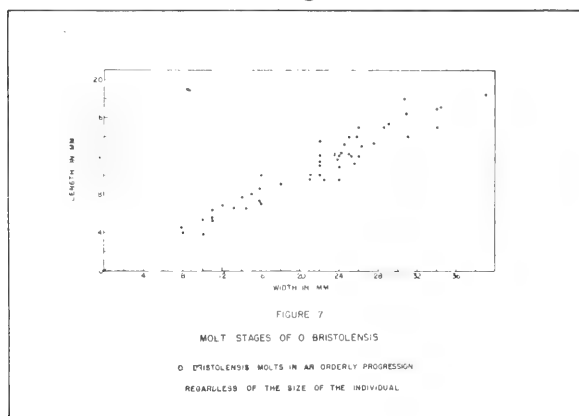
This species is closely allied to *P. clarki*. The intervening distance from the glabella to the rim is longer than in *P. clarki*.

CEPHALON

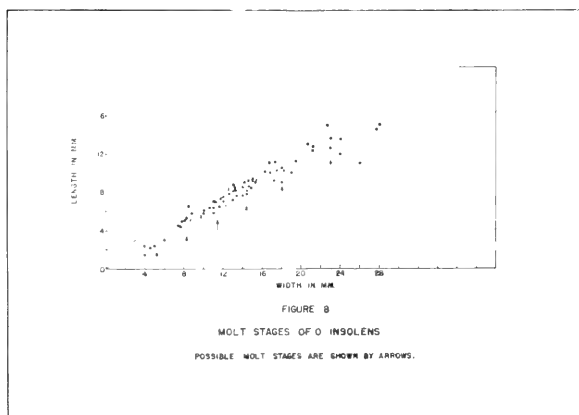
Most of the morphological entities of the cephalon indicate specialization among both *Paedeumias* and *Olenellus*. The cephalon is semi-circular in shape in species of both genera, except that *O. bristolensis* has a trapezoidal outline due to the advancement of the genal spines. All the specimens collected show segmentation of the glabella. Three glabellar lobes plus a large anterior or frontal lobe are present in front of the occipital ring. Furrows separating glabellar lobes are continuous in young molts but as maturity is attained the furrows appear as minute depressions on either side of the axis. The occipital furrow is clearly defined in all stages of growth. Increase in width of the anterior lobe of the glabella and the pushing forward of the anterior lobe of the glabella in *Olenellus* are indications of specialization.



Text Figure 6



Text Figure 7



Text Figure 8

Eyes of the olenellids are crescentic, with the palpebral lobes being more or less continuous with the anterior lobe of the glabella. Walcott (1910, p. 239) has shown that the Mesonacidae possess normal compound eyes. Oddly enough, not a single eye surface was observed among the hundreds of specimens studied herein.

Discussion of the facial suture, cephalic spines, and hypostoma are taken up independently as they constitute the more important finds made by the writer.

CEPHALIC SPINES

Three pairs of cephalic spines are known to occur in several species of the family Olenellidae, namely, *Leptoplastus salteri*, *Olenellus gilberti*, *Oleneloides armatus*, *Elliptocephalus asaphoides* and *Paedeumias transitans* (Raw, 1937, p. 582). Raw (1937, p. 575) differentiates between three types of trilobites on the basis of development of different primitive cephalic spines to form the genal spines. Among these types is the metaparial trilobite which Raw believes is characteristic of the Olenellidae. The metaparial trilobites are supposed to have rotated the procranidial spines, which are borne on the antero-lateral margin of the cephalon near the anterior angles of the cranidium, to the postero-lateral angles of the cephalon to form the genal spines. The intergenal spine is thought by Raw to be formed by the coalescence of the metacranidial spine, which is present at the postero-lateral edge of the cephalon, and the parial spine located approximately midway between the procranidial and metacranidial spines.

In the specimens obtained by the writer, the above cannot be ascertained except for the presence of the three pairs of spines. In *Paedeumias* the genal and intergenal spines are distinct and occur on or near the posterior border. On several specimens of *Paedeumias*, the third pair (the metacranidial spine), located axially from the intergenal spine, appears as a nodular thickening rather than as a spine. Apparently the third pair has been aborted without coalescing with the parial spine. In *O. insolens* the genal spines are located on the antero-lateral edges of the cephalon. Thus, if the genal spines migrated posteriorly as postulated by Raw, there must have been a reversal of migration. No evidence can be shown that this reversal took place. Raw (1937, p. 590) believes that the reversion in *O. insolens* may be attributed to its giving up the burrowing habit. The writer does not know of any evidence which can substantiate this. In a specimen of *O. insolens* studied herein, (unfortunately subsequently damaged) the parial and metacranidial spines appeared to be coalescing but the latter pair was shorter and was probably being aborted without coalescence with the former pair. Raw (1937, p. 583), however, only points to the actual posterior migration of

the procranial spine in *Leptoplastus salteri*, but believes he is justified in seeking to homologize the cephalic spines of *Paedeumias* and *Olenellus* with the three pairs of *Leptoplastus* because they are members of one family. Raw also postulates that the posterior migration of the procranial spine carried the anterior portion of the facial suture towards the genal angle. He goes on to say, "The sutures, however, in the above named species are represented by vestiges of the posterior branches only; so that, of the cranial spines, only the metacranial can be observed in relation to an adjoining suture — the posterior branch" (Raw, 1937, p. 583). The problem of whether or not the anterior suture is present will be taken up in a later section.

In the genus *Paedeumias* a second pair of spines persists as intergenal spines which are present near the lateral edge of the posterior rim and close to the genal spines. These occupy the same position on all specimens studied. Only small molts of *O. bristolensis* and *O. insolens* possess intergenal spines. Length of the intergenal spines is variable. Some specimens with a large cephalic diameter have longer intergenal spines than have those with a small cephalic diameter. The reverse condition should be expected. Inasmuch as the spines are aborted, increase in growth of the cephalon should imply smaller intergenal spines.

Sequence of molts of two species of *Olenellus* showing progressive loss of the intergenal spines are shown in Plates 5 and 8. Of the 161 specimens representing *O. insolens*, only 13 show intergenal spines. This feature is present in 8 molts of *O. bristolensis*. *O. fremonti* does not possess intergenal spines in either early ontogenetic or adult stages. Thus, it seems that intergenal spines were disappearing in *Olenellus*. In all specimens of *Paedeumias* studied herein, intergenal spines persist in all stages of growth. There seems to be no indication that the intergenal spines were being aborted.

The presence of intergenal spines is of generic importance in *Paedeumias* and also in *Olenellus*, even though the intergenal spines were disappearing in the latter genus. The intergenal spines may indicate a relationship of the two genera. If the biogenetic law is applied to these genera, it is possible to conclude that presence of intergenal spines in the molt stages is evidence of their having a common ancestor or that one was derived from the other.

FACIAL SUTURES

Another feature of the Olenellidae concerns the existence of facial sutures. Walcott clearly figured the course of the facial suture on *Olenellus gilberti*. In 1910 he repudiated this drawing and stated that, "In my hurried study of the *Olenellus* fauna in 1896 and 1891 I permitted facial suture lines to be represented in

front of the eye in a specimen referred to *O. gilberti* on evidence that now appears to me to be insufficient, as the line may have been formed by a fracture in the test" (Walcott, 1910, p. 242).

Raw accepted Walcott's view as to the absence of the anterior portion of the facial suture, and has attempted to show that the anterior portion of the facial suture migrated posteriorly along with the cephalic spines. Bell (1931, p. 17) has observed the anterior course of the facial suture in *Olenellus thompsoni*, and stated that "Since the sutures of the Mesonacidae are advanced in position and development, their rudimentary or vestigial structure is due to specialization rather than to primitiveness. They are, therefore, in a state of symphysis, being in a process of secondary fusion."

A number of specimens of *Paedeumias* and *Olenellus* obtained by the writer show a faint line extending forward from the anterior edge of the eye to the frontal rim of the cephalon and extending posteriorly from the lower third of the eye to the genal angle. The presence of the anterior facial suture would tend to eliminate Raw's line of reasoning in which he postulates that the procranial spines have evolved to the genal angles carrying the anterior portion of the facial suture.

Specimens of the Olenellidae possess facial sutures of an advanced opisthoparian types. They indicate that this family belongs to the order Opisthoparia.

HYPOSTOMA

Two distinct types of hypostomae were noted: one, on which the posterior margin is scalloped, and the other, in which the entire periphery lacks the scalloped edge (Plate 7, figs. 3-4).

The hypostoma of *Paedeumias* is more or less triangular in shape with a posterior scalloped margin separated from the main portion by a furrow which transects the entire surface. There are twelve scallops, the number remaining constant from specimen to specimen. A concentric pattern of inosculating ridges is present on the surface of the hypostoma.

The outline of the hypostoma, as shown by the genus *Olenellus*, is oval and lacks the scalloped appearance. Its margin is not separated from the main portion by a furrow, but in its place is a fold which occurs only on the lateral edges of the hypostoma. Its surface is similar to that of *Paedeumias*.

It is evident from the above discussion that the hypostoma is of generic and not of specific value.

THORAX

In *Olenellus* and *Paedeumias* the first fourteen segments are fully developed. The third segment is enlarged and the fifteenth possesses a large, long spine. All the segments decrease in size except the third. Plurae are straight with sharply curved, long, tapering ends.

POST-THORACIC SEGMENTS

Four specimens of *Olenellus* possess post-thoracic segments (Plate 6, figs. 1-3). The number of these segments varies from specimen to specimen, the greatest number being seventeen. None shows the last caudal segment. These segments are similar to the first fourteen in having pleurae, but are not as spinose nor do they have axial nodes or spines. Width of the rudimentary segments is comparable to that of the axial lobe. No distinction can be made between "axial" and "pleural" lobes because of the lack of distinct dorsal furrows. In cross-section the center portion is higher in comparison to its lateral extents. The surface of these segments is granular.

Specimens without post-thoracic segments occur above and below those displaying this feature. The writer cannot demonstrate whether or not rudimentary segments existed in all specimens. Absence of these segments may be possibly due to resorption or more probably they may have been broken off prior to entombment. However, no solitary post-thoracic segments were found. Burling believes that the rudimentary segments were aborted during the life of an individual. In considering the evolution of the Mesonacidae he states, "The resorption of segments posterior to the fourteenth in the Mesonacidae would seem to indicate that the functioning parts, those necessary for the life of the individual, were confined to the first fourteen. The finding of post-thoracic segments would seem to indicate that this resorption takes place laterally, that is, they become smaller in size before they become fewer in number" (1916, p. 55).

The appearance of post-thoracic segments is not unique among *Olenellus* and *Paedeumias*. In *Elliptocephalus* five segments are present posterior to the anterior thirteen. *Wanneria* and *Holmia* have progressively smaller segments posterior to the first thirteen and fourteen thoracic segments respectively. Burling (1916, p. 56) states that no suggestion of resorption of the post-thoracic segments can be seen in the latter two genera.

THIRD THORACIC SEGMENT

The enlargement of the third thoracic segment in the Olenellidae appears to be important from a morphological standpoint. Moreover, the close relationship of *Paedeumias* and *Olenellus* is shown by the fact that in each the third segment is enlarged. Greatest size of this segment is found in *Olenellus*, and in *O. bristolensis* the pleural portion of the third segment is enlarged more than in other representatives of the Olenellidae.

As to what the function of the third segment was, the writer

EXPLANATION OF PLATE 5

Figs. 1-13 — *Olenellus insolens* (Resser), 4X, Hypotypes, USC nos. 215-1 to 215-13. Showing molt stages with progressive loss of intergenal spines.....p. 30.

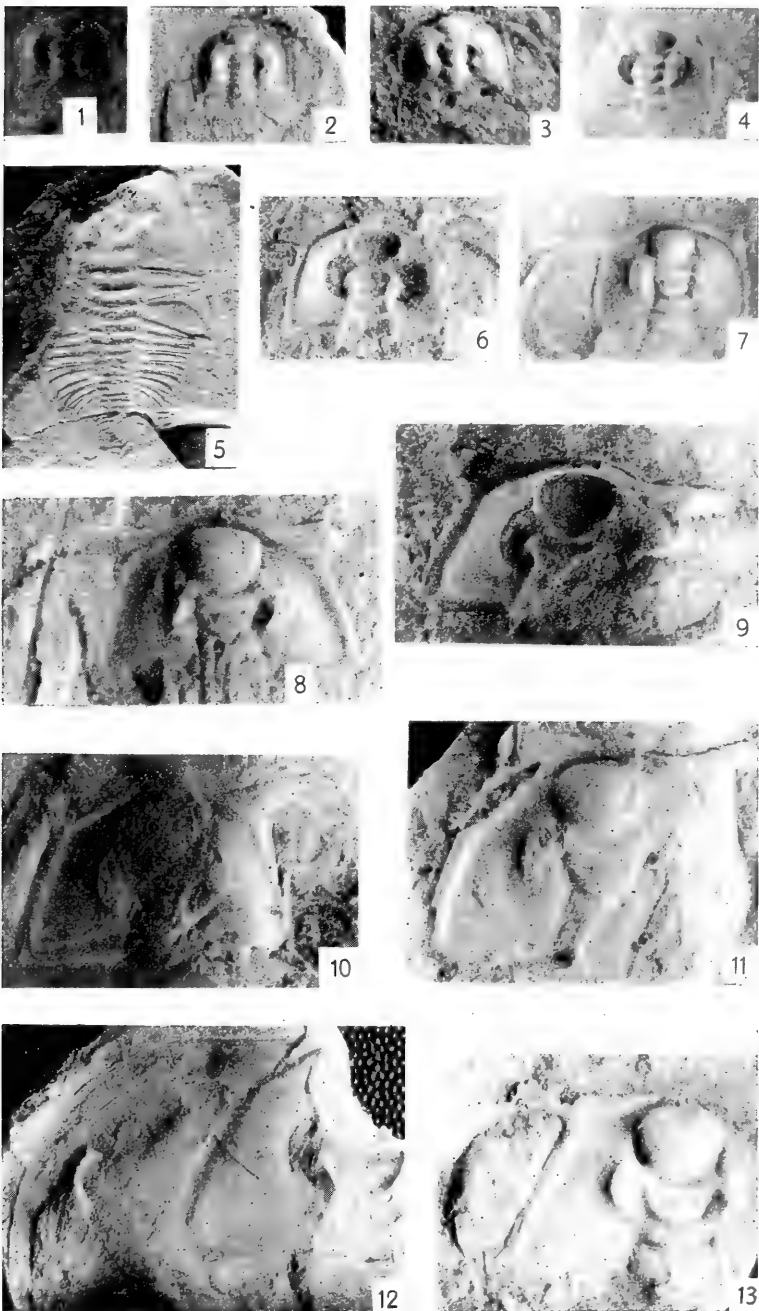


Plate 5

offers no explanation. Further study may yield results of morphologic value. Of the genera in which no suggestion of resorption of post-thoracic segments occurs (*Wanneria*, *Holmia*, and *Callavia*), *Callavia* alone shows a tendency toward an enlargement of the third thoracic segment. The genera with tendency toward resorption of post-thoracic segments (*Olenellus* and *Paedumias*) have an enlarged third thoracic segment (Burling, 1916, p. 57). Whether there is any relationship between the macropleural development of the third thoracic segment and the presence of post-thoracic segments cannot be demonstrated at present.

NODES

All specimens of *Paedumias* possess the occipital node or spine. In *Olenellus* the presence of the occipital node is lacking in some specimens. Whether the node is absent due to the mode of preservation or to variation in the individual cannot be ascertained. When present, the node is very evident. In early ontogenetic stages no differentiation of the glabellar lobes occurs and often these lobes retain vestiges of the axial spines. Presence or absence of occipital nodes in *Olenellus* may be the distinguishing character of sex. No proof, however, can be advanced.

Both genera possess axial spines on their first fifteen segments. In *Olenellus*, the post-thoracic segments are devoid of any type of spine or node.

SPECIES VARIATION

Evidences of variations within *O. bristolensis* exist in that the genal angle, shape of the cephalon, and the position of the genal spine vary. Resser (1928, p. 7) states that neither size nor age of individuals causes variation in the position of the genal spines. In order to show such variations, a mathematical method was employed in which a constant could be derived. This constant was chosen as the glabellar ratio in which measurements were taken from the tip of the glabella to a line extending from one genal angle to another and from that line to the end of the occipital ring so that the former was divided by the latter. These measurements were taken of *O. bristolensis* and *O. fremonti*. The latter species was included because at a casual glance it seemed that *O. bristolensis* evolved from *O. fremonti* by the increase in genal angle plus the advancement of the genal spines. The ratios obtained for the species were plotted on three cycle graph paper against the number of measured specimens, and a curve with two highs resulted which indicates two distinct species (fig. 2). If the curve represented by *O. bristolensis* had shown two highs, then the variations might be given specific rank.

EXPLANATION OF PLATE 6

Figs. 1-3 — *Olenellus insolens* (Resser), 4X, Hypotypes, USC nos.
215-14 to 215-16. Four specimens displaying post-thoracic
segmentsp. 30.

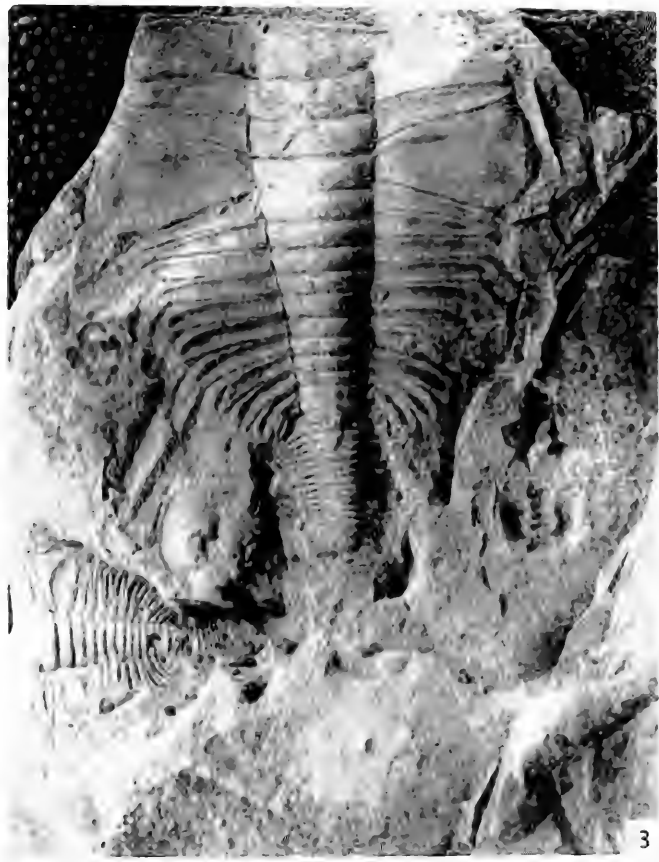
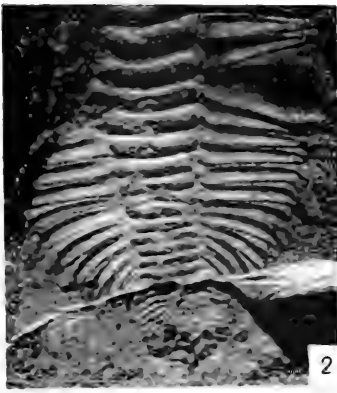


Plate 6

Inasmuch as the genal angle of *O. bristolensis* varies, a graph was made in which the degree of angle was plotted against the number of specimens. The resultant curve showed that the majority of the specimens have genal angles of 80 to 90 degrees. Fewer forms have an angle greater than 90 degrees than have genal angles from 44 to 80 degrees (fig. 4).

To determine if any relationship exists between the size of the genal angle and the glabellar ratio of *O. bristolensis*, data were plotted on three cycle graph paper. The net result was a scattering of points and no curve could be drawn (fig. 3). It seems, then, that the size of the genal angle bears no relationship to the glabellar ratio and that the glabellar dimensions and the genal angle vary independently of each other. Inasmuch as the data plotted above were obtained from specimens displaying varying amounts of genal angle, it was thought that those specimens displaying equal amounts of genal angle might tend to show an equal rate of development. Data were plotted on three cycle graph paper and the result was a scattering of points. No curve could be drawn. Therefore, regardless of whether the specimens display varying amounts of genal angle or the same amount of genal angle, the glabellar ratio and the genal angle vary independently of each other.

Length of the glabella was plotted against the glabellar ratio to determine if any correlation exists between the maturity of the specimens and dimensions of the glabella. Because the position of the genal spines determines the glabellar ratio as well as one side of the genal angle, the relationship that would be expressed in the correlation would tend to show if maturity is a function of the length of the glabella, genal angle, and position of the genal spines. Data were plotted for both *O. bristolensis* and *O. fremonti* to ascertain the above and to see if the two highs represented in fig. 2 presented a true picture. The resultant curve (a scattering of points) showed that maturity plays no part in the relationships expressed above. The points representing each species, however, did fall into two restricted zones (fig. 5). This indicates that the specific distinction represented by fig. 2 is correct.

Obviously, the shape of the cephalon is related to the position of the genal spines. With advancement of these spines, the cephalon takes on a trapezoidal outline. Whether the advancement is an evolutionary process or a change due to molting is a moot question. Specimens showing all variations come from a shale section three feet thick, so it seems probable that it is a change due to molting and not to evolutionary processes.

EXPLANATION OF PLATE 7

- Figs. 1, 2, 5 — *Olenellus bristolensis* (Resser), 2X, Hypotypes, USC nos. 214-12 to 214-14. Showing varying shapes of the cephalon and amounts of genal angle.....p. 30.
 Fig. 3 — Hypostoma of *Olenellus*, 4X, USC no. 900.
 Fig. 4 — Hypostoma of *Paedeumias*, 4X USC no. 899.
 Fig. 6 — *Olenellus fremonti* Walcott, 1X, Hypotype, USC nos. 213-1, 213-2p. 30.

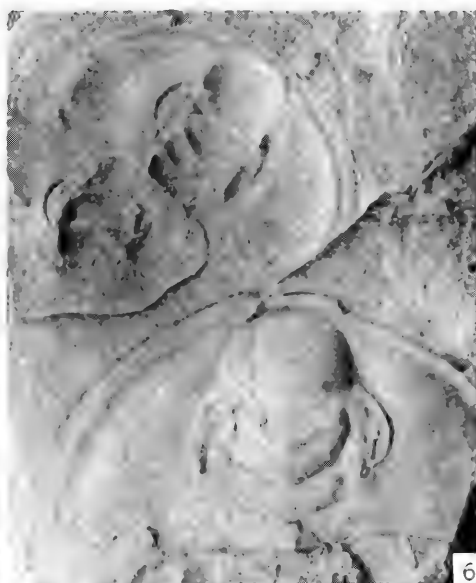
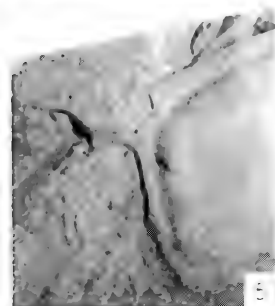
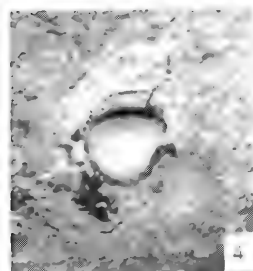
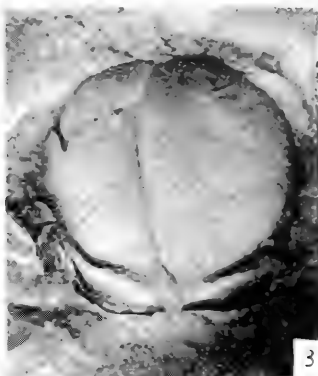
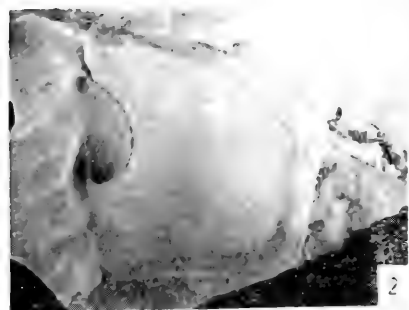


Plate 7

In order to see if there were any variation in *O. insolens* in the point of origin of the advanced genal spines, the same method of measurement was employed for 38 specimens as was used for *O. bristolensis*. The resultant curve was a straight line, indicating that there was no variation in the point of origin of these spines. This verifies an observation previously stated by Resser (1928, p. 8). The points which do not fall on an absolutely straight line are possibly due to the mechanical difficulties in measuring or to the preservation of the fossils. Numerous duplication of points occurred (fig. 6). From this it can be inferred that the rate of advancement of the genal spines keeps pace with the maturity of the specimens.

MOLT STAGES

The determination of the number of molt stages for several species of *Olenellus* and *Paedeumias* was attempted by the writer. Measurements of the cephalon were taken with a micrometer to the closest tenth of a millimeter. Width along the posterior border was plotted on arithmetic graph paper against maximum length of the cephalon. Thus, if the trilobites have coordinated stages in molting, points representing molts should fall in groups along a straight line. Points for all specimens measured did fall on a straight line but no grouping could be adequately discerned. Evidently the trilobites did not molt at particular stages but molted in an orderly progression regardless of the size of the individual.

Of the 114 specifically identifiable specimens of *O. bristolensis* only 51 could be adequately measured for use in this study. The points for this species fell on a straight line, but not on a line passing through zero (fig. 7). Evidently, the width of the cephalon increases more rapidly in growth than does the length. In determining if any relationship existed between the glabellar ratio and the genal angle of *O. bristolensis*, it was noted that these varied independently of each other. However, the length and width of the cephalon do not vary independently of each other, inasmuch as the points fall on a straight line. It seems that there is an unequal rate of growth for some entities of the cephalon whereas the size of the cephalon is defined by an orderly rate of growth. No absolute groupings of points to represent molt stages can be seen in fig. 7 although there are possible groups.

Sixty-one specimens of *O. insolens* were measured and plotted on graph paper as was done for *O. bristolensis*. The points again fell on a straight line, there being an orderly progression of growth for the cephalon. Vague grouping of points can be seen in fig. 8.

EXPLANATION OF PLATE 8

- Figs. 1-8 — *Olenellus bristolensis* (Resser), 4X, Hypotypes, USC nos. 214-1 to 214-8. Showing molt stages with progressive loss of intergenal spines.....p. 30.
Figs. 9-11 — *Olenellus bristolensis* (Resser), 4X, Hypotypes, USC nos. 214-9 to 214-11. Showing varying shapes of the cephalon and amounts of genal angle.

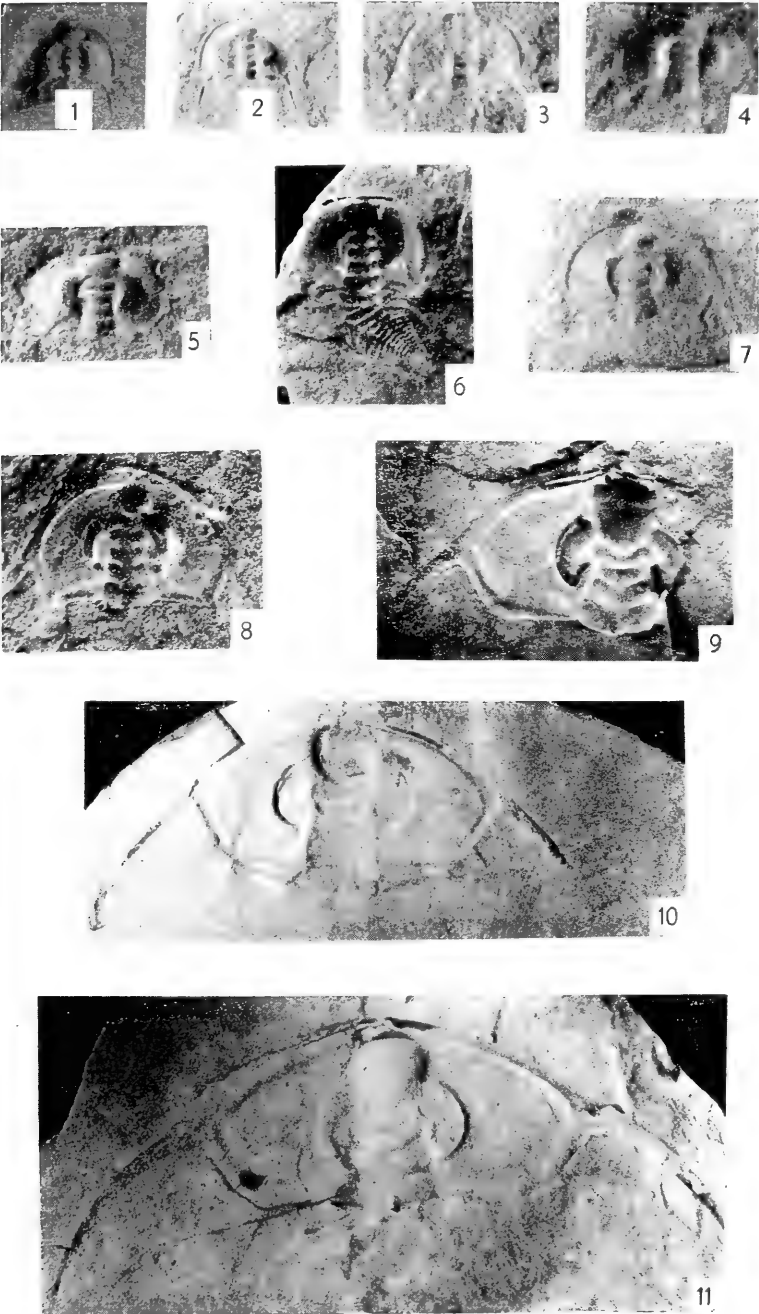


Plate 8

If the groups represent molt stages, there may be a maximum interval of molting as represented by specimens with a width of the cephalon from 7 to 16 millimeters. Possible groupings representing molt stages are shown by arrows. The writer does not claim that the groupings actually represent molt stages. Possibly the groupings are due to the lack of measurable specimens for intervening spaces on the graph.

Data plotted for *P. clarki* and *P. nevadensis* showed similar results that were obtained for the two species of *Olenellus* (figs. 9-10). Measurements could not be readily taken of *O. fremonti* and therefore were not plotted. *P. mohavensis* is only represented by seven specimens and so plotted data would not be significant.

CONCLUSION

All indications tend to point to the fact that the Olenellidae is a specialized family of trilobites. The resorption of one or two pairs of cephalic spines plus the increase in width of the frontal lobe of the glabella indicate that the cephalon is specialized. Presence of the complete facial suture, even though fused, also points to specialization. The third enlarged segment together with the post-thoracic segments indicates additional specialization and seems to bear out the fact that the Olenellidae were far advanced in evolution.

Molting and not evolutionary processes accounts for the observed variations in *O. bristolensis*. The amount of genal angle, position of the genal spines, and the glabellar ratio vary independently of each other. No correlation exists between the above and the maturity of the specimens. Forms displaying the same amount of genal angle do not have the same rate of development. The rate of advancement of the genal spines in *O. insolens* is directly correlated with the maturity of the specimens.

Intergenal spines are present in *O. bristolensis* and *O. insolens* and even though these spines abort in early ontogenetic stages they are of generic value. The presence of intergenal spines in *Olenellus* and *Paedeumias* may indicate a phylogenetic relationship between the two genera.

Inasmuch as the anterior course of the facial suture can be demonstrated in specimens of *Paedeumias* and *Olenellus*, its presence indicates that the Olenellidae belongs in the order Opisthopteria.

The two types of hypostoma are distinct from each other and are of generic and not of specific value.

EXPLANATION OF PLATE 9

- Figs. 1-4 — *Paedeumias clarki* Resser, 2X, Hypotypes, USC nos. 211-1 to 211-4.....p. 33.
 Figs. 5-6 — *Paedeumias nevadensis* (Walcott), 2X, Hypotypes, USC nos. 212-1, 212-2.....p. 33.
 Figs. 7-8 — *Paedeumias mohavensis* Crickmay, 3X, Hypotypes, USC nos. 210-1, 210-2.....p. 33.
 Fig. 9 — *Paedeumias* sp., 6X, USC no. 901. Showing three pairs of cephalic spines.

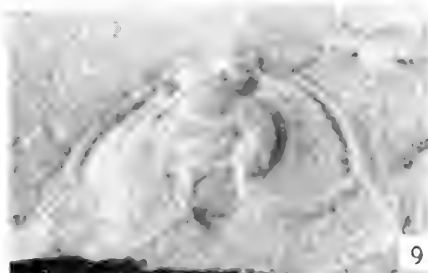
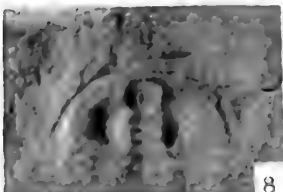
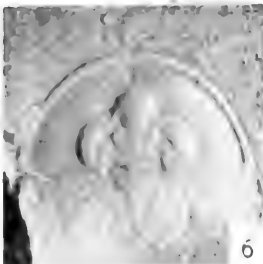
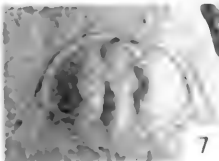
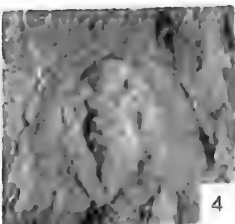
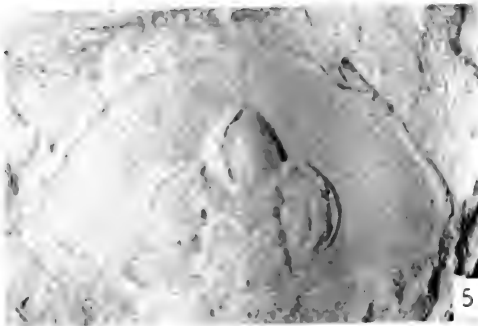
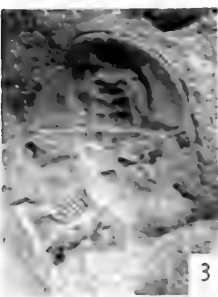
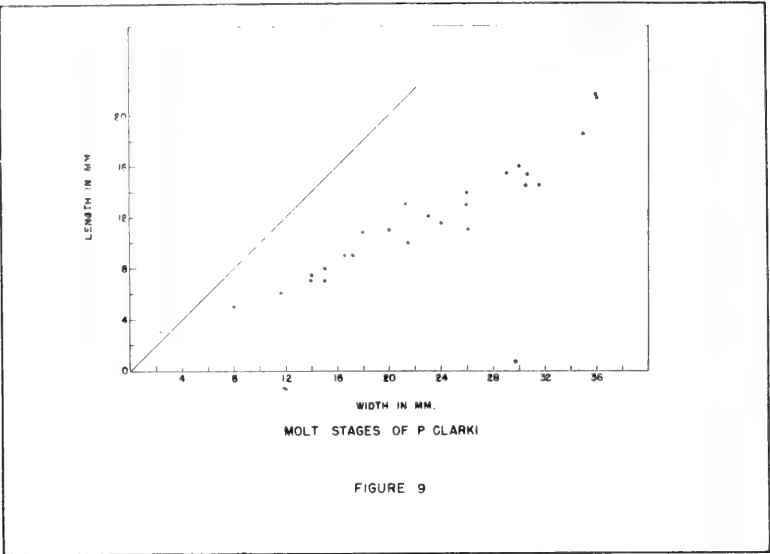
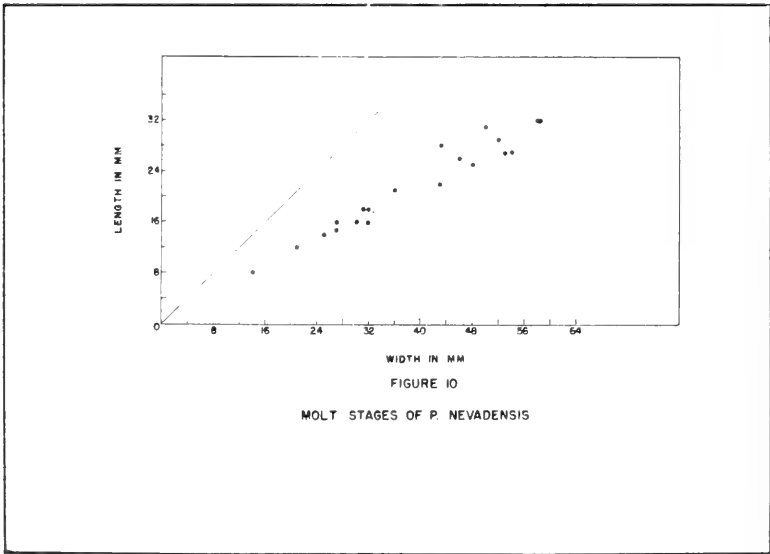


Plate 9
47

Trilobites studied herein do not molt at particular stages but molt in an orderly progression regardless of the size of the individual. Groups of points, which may represent possible molt stages, fall in a straight line. The straight line indicated that for



Text Figure 9



Text Figure 10

all species studied the width of the cephalon increases more rapidly than does the length in growth. In *O. bristolensis*, there is an unequal rate of growth for some morphological entities of the cephalon whereas its size is defined by an orderly rate of growth.

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THE PREHISTORIC AVIFAUNA OF SMITH CREEK CAVE, NEVADA, WITH A DESCRIPTION OF A NEW GIGANTIC RAPTOR

By HILDEGARDE HOWARD

In an earlier paper (Howard, 1935, *Condor* 37:206-209), I discussed briefly the occurrence of extinct birds in a cave deposit in Smith Creek Canyon, White Pine County, Nevada. A new species of eagle, *Spizaetus willetti*, was described, and *Breagyps clarki* and *Coragyps occidentalis* were recorded. Later, Stock (1936, *Bull. Southern Calif. Acad. Sci.*, 35:149-153) described an extinct goat, *Oreamnos americanus*, from this cave, and recorded the occurrence of *Camelops*, *Equus* and *Ovis*.

Smith Creek Cave was originally investigated by the Southwest Museum in the hope of finding evidence of early man. Two expeditions, sponsored by the Carnegie Institution of Washington, were made in 1934 and 1936. Harrington (1934, *Master Key*, 8:165-169) reports that traces of fairly recent Indians were found in the upper 12 inches of the dust which covered the cave floor. In the older deposits, of lower levels, however, in which the interest of the expeditions centered, the only suggestions of human habitation were occasional bits of charcoal and the fact that many of the mammal bones were split as if broken to obtain the marrow. The cave site as described by Harrington lies in a rugged desert canyon about 1000 feet above Smith Creek, at an elevation of approximately 6200 feet. At the mouth of the canyon, less than a mile from the cave, lies the great desert valley of Utah filled at one time by an arm of Lake Bonneville. In the opposite direction rises Mount Moriah, topped with pines. Like many discoveries of prehistoric bone deposits made within the past several years, the question of age has not been definitely determined. Harrington suggests that the presence of fish bones in the deposits may indicate that the accumulation took place at the time when the lake bed to the east was filled, presumably late in the last period of glaciation.

The deposits in Smith Creek Cave were composed of exceedingly loose dust, very difficult to excavate and maintain data on depth. Bird and mammal bones were found at all levels from 1 to 12 feet. The bird bones were turned over to me for study several years ago, but, as further expeditions were planned, publication of a complete list of species identified was postponed. In February of this year (1952) I discovered among the mammal bones collected on the expeditions, and now housed at the California Institute of Technology, a very large carpal bone (cuneiform) of a raptor. The bone had obviously been overlooked when the other bird bones were sorted, owing to the large size.

Compared with the cuneiforms of various known raptors, the cave bone most closely resembles that of vultures, especially *Teratornis*. It is not, however, identical in structural characters with any species with which it was compared, and it is very much larger than the largest, measuring 43.2 mm. in greatest breadth, with a height at the ulnar end of 32.8 mm. and a depth of 22.8 mm. The same dimensions of the cuneiforms of Recent California Condor (*Gymnogyps californianus*) and of *Teratornis merriami* (Pleistocene of Rancho La Brea) are: Condor (L. A. Mus. no. 269), 21.0, 17.0 and 12.7 mm. respectively; *Teratornis* (L. A. Mus. no. B414), 30.0, 24.5 and 15.6 mm. respectively. Although the paleontologist would ordinarily hesitate to describe a new species on the basis of a single cuneiform bone, in this instance the distinctiveness of the specimen is so marked that it seems justifiable. I do not consider it advisable, however, to name a new genus without further knowledge of the bird. Allocation to the genus *Teratornis* is therefore made on the basis of general similarity to *Teratornis merriami* as indicated below.

***Teratornis incredibilis* new species**

TYPE. — Cuneiform bone, California Institute of Technology no. 5067.

LOCALITY AND AGE. — Section 7-F-310 of Locality 251, Smith Creek Cave, Snake Range, 34 miles north of Baker, White Pine County, Nevada. Quaternary.

DESCRIPTION. — Resembling *Teratornis* (family Teratornithidæ) as contrasted with *Gymnogyps* and other members of the family Cathartidæ, in (1) long, diagonal, ridgelike ligamental attachment on the side of the bone adjacent to the ulna, and (2) close proximity of this diagonal ridge to the external prominence; the ligamental attachment is short, almost papilla-like in the Cathartidæ, with a broad space between it and the external prominence. Differing from *Teratornis merriami* in (1) 43 per cent greater size; (2) greater pneumaticity; (3) longer and relatively less peaked external prominence; (4) more prominent ligamental attachment adjacent to the ulna; (5) relatively greater breadth of posterior (distal) end.

Obviously the bird was a flier. The cuneiform receives the attachment of part of the flexor carpi ulnaris muscle (affecting manipulation of the manus in flight) and provides a groove for passage of its tendon. The areas concerned with attachment and passage of this muscle are well developed in the type of the new species. The implications of the specimen as to the size of this flying bird justify the specific name applied — *incredibilis*. The breadth of the bone suggests a breadth of trochlea of carpometacarpus of 24-25 mm.; the size of the ulnar articulation indicates a height of carpal condyle of the ulna of 33 mm. By comparison

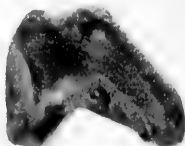
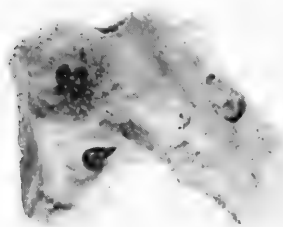


Figure 1

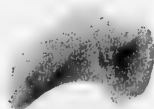
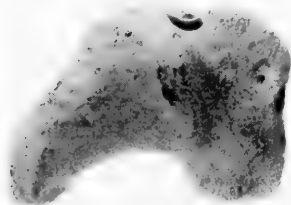


Figure 2

Plate 10

Figures 1 and 2. Left to right: Cuneiform bones of *Teratornis incredibilis* (Type); *Teratornis merriami*; and *Gymnogyps californianus*. Fig. 1 ulnar face; fig. 2 metacarpal face. X approx. 6/7.

with *Gymnogyps* the wingspread may have been as much as 16-17 feet, if the wing length was proportionate to the size of this one wing element. The California Condor today has a maximum spread of 9-10 feet; that of *Teratornis merriami* is estimated at 11-12 feet.

Although over 648 bird bones from Smith Creek Cave have now been examined, no other specimens of *Teratornis incredibilis* have been found. A thorough search has been made of all osteological material collected from the cave, mammal as well as bird.

Fifty species of birds have been identified from the avian material collected from the old deposits of the cave. Possibly still other species are represented among the bones of ducks and shorebirds. These forms are not readily separated, and detailed identifications were not possible on all bones. With the exception of extinct species, only two of the forms identified do not occur in Nevada today, *Gymnogyps californianus* and *Strix occidentalis*. *Gymnogyps* has been recorded, however, from Gypsum Cave,

Nevada, dated at 8,000 to 10,000 years old. The identification of the Spotted Owl is based on a single coracoid. The most abundant species represented are the Sage Grouse, *Centrocercus urophasianus* (122 specimens), Prairie Falcon, *Falco mexicanus* (117 specimens) and the extinct condor, *Breagyps clarki*. *Breagyps* is represented without doubt by 58 bones; another 32 fragments, plus 34 vertebræ and 22 phalanges, probably are of this condor rather than *Gymnogyps*. Five fragments are tentatively classified as *Gymnogyps*. More than half of the Prairie Falcon bones are of young birds. Obviously the cave represents the natural breeding habitat of this species. At least six individual condors (*Breagyps*) are represented, one of which was immature. Possibly *Breagyps*, too, used the cave as a nesting site at intervals.

Over fifty per cent of the bones represent raptorial species (353 bones of 16 species, including 8 specimens of 4 species of owls); 22 per cent are water birds (140 bones of 20 or more species, the surface-feeding ducks being the most abundant with 104 specimens); and 19 per cent are grouse (125 bones of two species). The remainder are of passerines (26 bones, of which 17 represent the Raven), swift, nighthawk, and dove (one each).

The good representation of water birds adds credence to Harrington's suggestion (above mentioned), based on the fish bones found in the cave, that the old lake bed to the east may have contained water at the time the cave deposits were accumulating. Presumably the water birds, as well as many of the other species of birds, were carried to the cave by predators. The abundant Sage Grouse and Prairie Falcons, as well as the formerly reported (Stock, loc. cit) horse, sheep, goat and camel all indicate that the immediate area in the past was much as it is now, a relatively bare, open land — perhaps then bordering on an interior lake.

Six extinct species occur, represented by at least 67 bones. Possibly there are more, if the unidentified condor bones are of *Breagyps* rather than *Gymnogyps*. Two of the six species, *Spizaëtus willetti*, and *Teratornis incredibilis*, are peculiar to Smith Creek Cave. *Coragyps occidentalis* (2 specimens) has been recorded from other cave deposits in California, New Mexico and Mexico, as well as from the three asphalt deposits of California. *Breagyps clarki* has been reported elsewhere only from the Rancho La Brea deposits of California (its type locality). *Neogyps errans* (2 specimens) and *Anabernicula minuscula* (3 specimens) are also now recognized from the Smith Creek Cave deposits. *Neogyps* is known from the Mexico and California Pleistocene; *Anabernicula* was first described from Arizona (early Pleistocene) and later reported from the late Pleistocene asphalt beds of California and from Fossil Lake, Oregon. Of these extinct forms, only *Breagyps* occurs in sufficient abundance to indicate that it was common in the cave.

It is worthy of note that in addition to the two bones of *Coragyps* found in the deeper levels, two bones of *Cathartes aura* (evidently of the same individual bird) were found near the surface in the cave floor. Both show a state of preservation different from the majority of bones found and appear to be of much more recent deposition. It has been previously indicated by studies of deposits of different ages at Rancho La Brea (Howard and Miller, 1939, Carnegie Inst. Wash. Pub. 514, p. 44) that *Coragyps* was the dominant form of small vulture in the Pleistocene of California, but was supplanted by *Cathartes* in more recent time. It is now suggested that the same condition existed in the Nevada area and that the occurrence of *Coragyps* without *Cathartes* in the deeper levels of Smith Creek Cave bears some significance with regard to the age of the older fauna.

A complete list of the avian species now identified from Smith Creek Cave follows. Extinct species are marked with an asterisk. The species represented by a single specimen are so indicated. Exact numbers of bones of the anseriform species cannot be determined, although the total of all duck bones is 109, of which at least 30 represent the teals, and only 5 are of the Aythyini. *Aquila chrysaetos*, *Corvus corax* and *Fulica americana* are represented by 30, 17 and 9 bones respectively. Other species vary in number from 2 to 5 (with the exception of the Sage Grouse, Prairie Falcon and extinct condor previously discussed). The passerines were kindly identified by Dr. Alden H. Miller.

LIST OF SPECIES

Podilymbus podiceps (1)	Falco sparverius
Colymbus caspicus	Fulica americana
Branta canadensis	Rallus, sp. (1)
*Anabernicula minuscula	Centrocercus urophasianus
Anas platyrhynchos	Pedioecetes phasianellus?
Anas acuta	Catoptrophorus semipalmatus
Anas carolinensis	Recurvirostra americana (1)
Anas discors?	Phalarope, sp. (1)
Mareca americana	Capella gallinago? (1)
Spatula clypeata (1)	Himantopus mexicanus?
Aythya marila	Zenaidura macroura (1)
Aythya, sp.	Bubo virginianus
Melanitta perspicillata (1)	Asio flammeus
*Teratornis incredibilis (1)	Strix occidentalis? (1)
*Breagyps clarki	Aegolius acadica (1)
Gymnogyps californianus?	Chordeiles minor (1)
*Coragyps occidentalis	Aeronautes saxatilis (1)
*Neogyps errans	Nucifraga columbiana? (1)
*Spizaetus willetti (1?)	Corvus corax
Aquila chrysaetos	Corvus brachyrhynchos
Buteo jamaicensis	Pica pica (1)
Buteo swainsoni	Turdus migratorius (1)
Buteo lagopus	Agelaius, sp. (1)
Circus hudsonius	Jay, sp. (1)
Falco mexicanus	Fringillidae, sp. (1)

Los Angeles County Museum, May 1, 1952

A NEW AMPHIPOD OF THE GENUS
CERADOCUS (*DENTICERADOCUS*)
FROM LOWER CALIFORNIA*

By J. LAURENS BARNARD
University of Southern California

Recent carcinological collections made by the research vessel *VELERO IV* along the coast of Lower California showed the presence of an amphiod genus (Crustacea) not previously reported from Pacific America. The present material differs greatly from any other known species of the genus and subgenus *Ceradocus* (*Denticeradocus*), to which this new species belongs, and which was ably discussed by Sheard (1939).

The writer wishes to acknowledge the many considerations of Dr. John S. Garth of the Allan Hancock Foundation and the generous support of Dr. James W. Buchanan, Director of Research at the Foundation.

***Ceradocus* (*Denticeradocus*) *paucidentatus*, new species**
(Plates 11-13)

DESCRIPTION OF MALE. — Head about as long as first 2 body segments, lateral lobes separated from lower head angle by a deep, narrow sinus, eyes moderately large in size, subcircular in outline.

Antenna 1 reaching about to end of peræon segment 7, article 2 of peduncle longer than 1, flagellum shorter than peduncle, accessory flagellum composed of 5-6 articles.

Antenna 2 shorter than 1, article 5 shorter than 4.

Upper lip evenly rounded below.

Mandible: accessory plate present in both mandibles, spine row with 7-8 spines, inner edge of palp article 1 acutely produced, article 3 about one third as long as 2.

Lower lip with inner lobes.

Maxilla 1: inner edge of inner plate heavily setose, outer plate with 9 spines, apex of palp with 13 slender spines.

Maxilla 2: inner plate with inner edge heavily setose.

Maxilliped: apex of inner plate obliquely truncated, defined laterally by small cusps, lined with 7-8 plumose setæ; outer plate not reaching to end of palp article 2, inner edge with stout, simple spines, apex of palp article 4 armed with a spine.

Gnathopod 1: coxal plate acutely produced forward, articles 5 and 6 subequal in length, palm oblique, setose, not defined, article 7 overlapping palm.

Gnathopod 2 of two sorts, one side larger than the other: (1) large gnathopod with palm oblique, with 2 processes near finger hinge separated by a narrow sinus, each process armed with 3-4

*Contribution No. 78 from the Allan Hancock Foundation, The University of Southern California.

and 5 spines, respectively, from finger hinge, palm defined by a large, blunt process, behind which is a smaller process; article 7 fitting palm; (2) the smaller gnathopod with the palm convex and lined with spinules, palmar angle acutely produced.

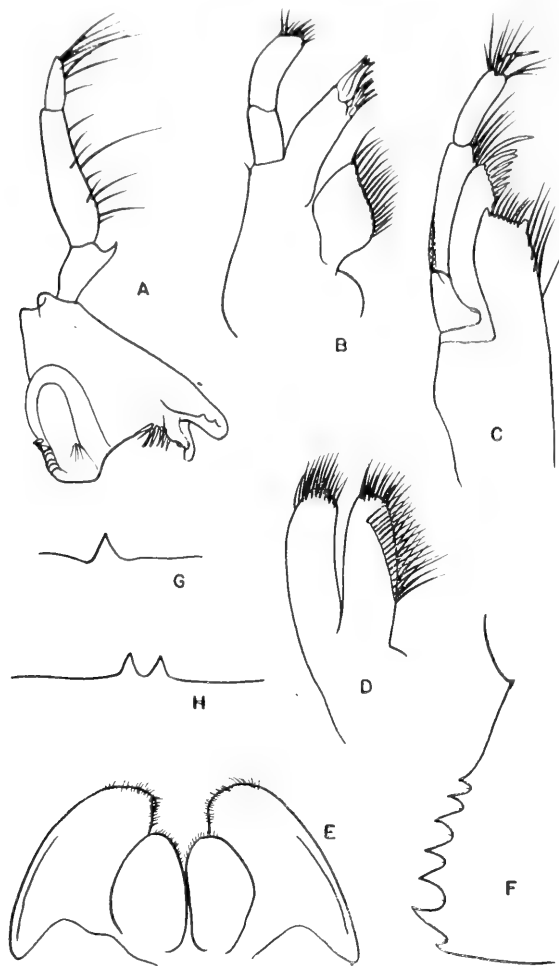


Plate 11

Ceradocus (Denticeradocus) paucidentatus, new species.

Paratype, male, 7 mm.

Fig. a, mandible; b, maxilla 1; c, maxilliped; d, maxilla 2; e, lower lip; h, dorsal teeth of pleon segment 4.

Holotype, male, 8 mm.

Fig. f, posterolateral edge of pleon segment 3, right side; g, dorsal tooth of pleon segment 4.

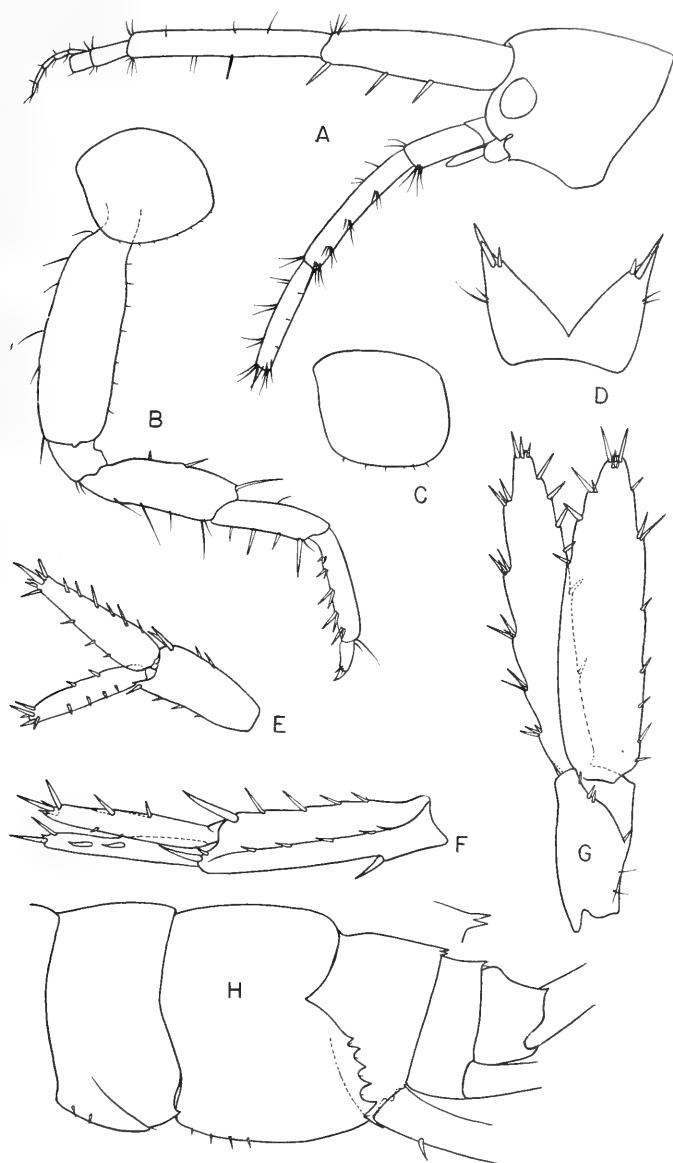


Plate 12

Ceradocus (Denticeradocus) paucidentatus, new species.

Paratype, male, 7 mm.

Fig. a, head and antennal peduncles; b, peraeopod 1; c, coxa of peraeopod 2; d, telson, enlarged; e, uropod 2; f, uropod 1; g, uropod 3; h, pleon segments 2 to 6.

Peræopod 1 larger than 2.

Peræopods 3-5 successively longer, similar. Lower posterior corner of article 2 produced downward into a broad lobe, posterior edge of article 2 serrate, more strongly so in peræopod 5 than peræopod 3.

Uropods 1 and 2 extending the same distance, rami of uropod 1 shorter than peduncle; of uropod 2, the inner ramus longer than peduncle.

Uropod 3 long, rami broad, flat, about twice as long as peduncle.

Telson: lobes apically acute, inner edges strongly incised, each armed with 2 spines, each outer edge with 2 setæ.

Pleon segments 1-3 not dorsally serrated; lower posterior corner of pleon segment 2 acutely produced; lateral posterior edge of pleon segment 3 with 6-7 large, acute teeth.

Dorsal edge of pleon segment 4 with 1-2 small, acute teeth, dorsal edge of segment 5 with 1 small tooth.

FEMALE. — UNKNOWN.

TYPES. — Holotype, AHF No. 514, male, 8 mm.; paratypes, 2 males, each 7 mm.

TYPE LOCALITY. — "Nameless cove, 12 miles east of Punta Eugenia, Lower California, shore, under rock. Location of cove: 27° 50' 00" N, 114° 51' 30" W. October 31, 1951.

MATERIAL EXAMINED. — The types.

REMARKS. — This species is characterized by the paucity of dentation on urosome segments 1 and 2, urosome segment 1 having 1 or 2 sharp teeth, segment 2 having only 1 tooth. It is also characterized by the absence of serrations on pleon segments 1 and 2, the lack of dorsal serrations on segment 3, the paucity of telson spination, and by the character of the lower posterior corner of peræopods 3-5.

The variability of pleon segment 4 dentation makes it difficult to fit into Sheard's (1939) key where one must choose between "pleon segments 4 and 5 with a large medio-dorsal tooth" and "pleon segments 4 and 5; evenly dentate." It is probably best to regard the present species as having a single mediodorsal tooth on these segments, although one of the paratypes has 2 teeth on segment 4. In this first category the new species differs from *Ceradocus* (*Denticceradocus*) *capensis* Sheard (1939) by the distinguishing characters mentioned above in the first paragraph of "Remarks." The species resembles *C. (D.) rubromaculatus* (Stimpson) and *C. (D.) sheardi* Shoemaker (1948) in the paucity of telson spination but again differs from them by the aforementioned characters, with the exception of the telson armature.

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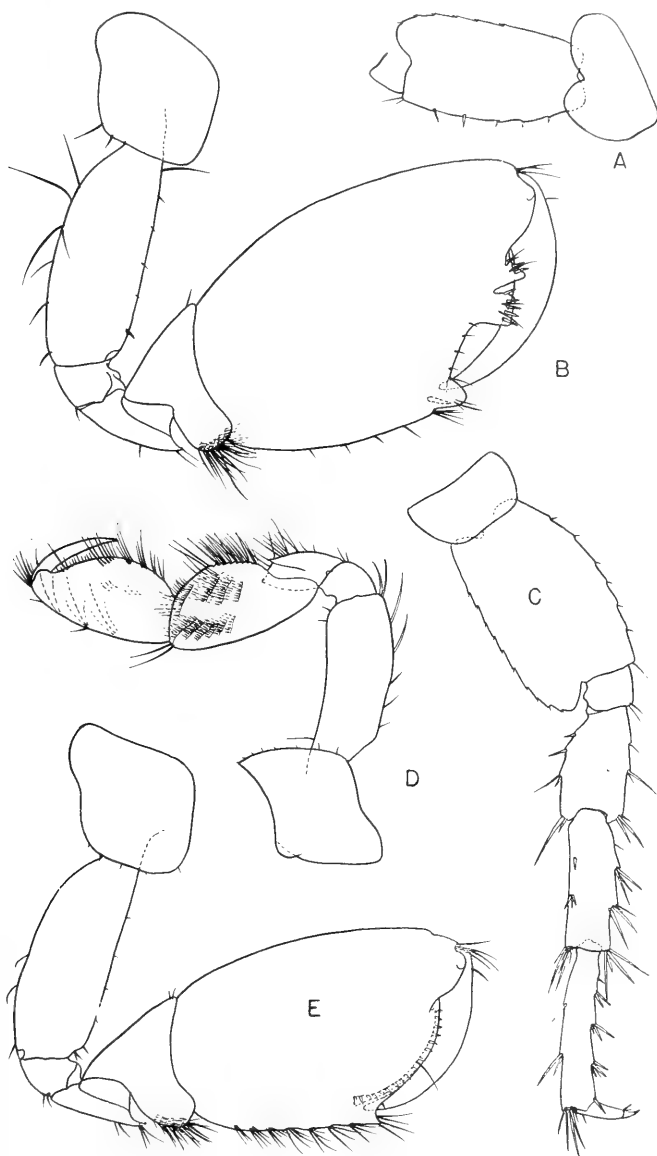


Plate 13

Ceradocus (*Denticeradocus*) *paucidentatus*, new species.

Paratype, male, 7 mm.

Fig. a, peræopod 3, coxa and article 2 only; c, peræopod 5; d, gnathopod 1; e, gnathopod 2, one side.

Another paratype, male, 7 mm.

Fig. b, gnathopod 2, showing the other form of this appendage, compare with fig. e.

TWO NEW SPECIES OF OLETHREUTIDÆ FROM CALIFORNIA (LEPIDOPTERA)

By J. F. GATES CLARKE

Bureau of Entomology and Plant Quarantine, Agricultural Research
Administration, United States Department of Agriculture

The following two species, received for determination, proved to be undescribed. Since both require names, they are offered below.

Eucosma hasseanthi, new species

(Plate 14, Figures 1, 3)

Alar expanse, 24-26 mm.

Labial palpus light ochraceous-buff with light brown mottling exteriorly on second segment. Antenna light ochraceous-buff annulated with light brown. Head, thorax and forewing light ochraceous-buff; thorax and tegula suffused with tawny, especially anteriorly; forewing with a coarse, but obscure, tawny reticulum; middle of dorsum with an outwardly oblique purplish-fuscon blotch extending to middle of wing; in some specimens continuing to costa as an inwardly oblique transverse fascia; from cost^a, slightly before apical third, an outwardly oblique, purplish-fuscon, transverse fascia extends nearly to termen at vein 4; ocelloid patch indicated by a few scattered black scales; cilia concolorous with ground color of forewing and with a narrow, light brown sub-basal line. Hind wing light brown; cilia light ochraceous-buff with light brown sub-basal line. Legs light ochraceous-buff; fore and mid-femora and tibiæ shaded with tawny; fore and mid-tarsi brown. Abdomen light ochraceous-buff.

MALE GENITALIA. — Harpe as figured. Uncus reduced; socii weak, fleshy lobes. Aedeagus short, stout.

FEMALE GENITALIA. — As figured. Signa unequal; one large, one small.

TYPE. — U. S. National Museum No. 61472.

TYPE LOCALITY. — Orange, California.

FOOD PLANT. — *Hasseanthus variegatus* (Wats.) Rose.

REMARKS. — Described from the type male, one male and three female paratypes all from the same locality. Emergence dates are 1.23.viii.36 (T. W. Hower). Paratypes in the U. S. National and Los Angeles Museums.

This species is nearly related to both *primulana* and *biplagata*. It differs from *primulana* by the absence of the apical mark and from *biplagata* by the presence of a reticulated pattern and darker ground color.

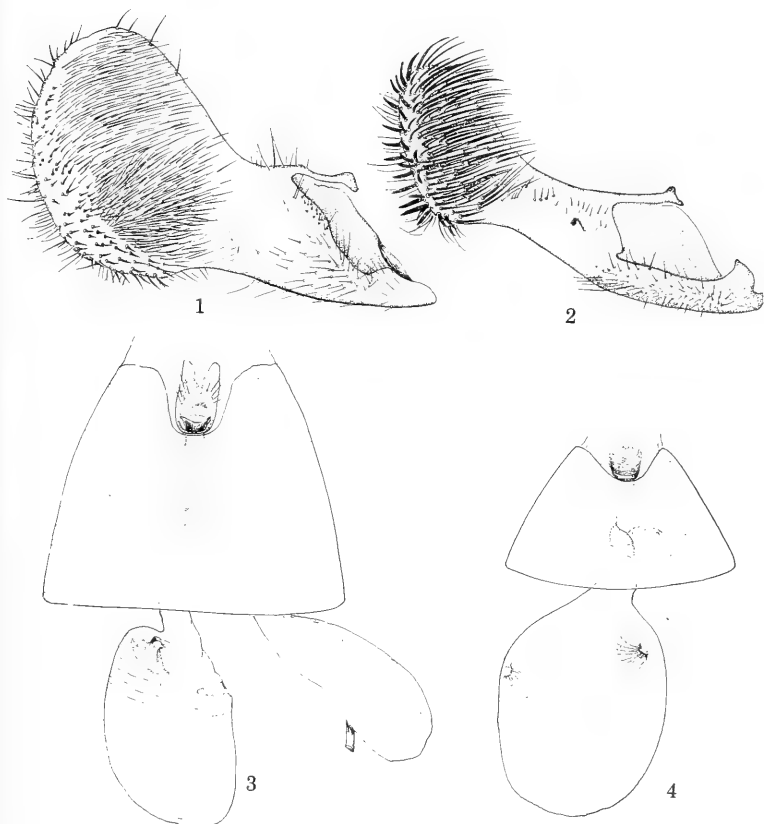


Plate 14

Eucosma hasseanthi, new species: Fig. 1, left harpe; Fig. 3, ventral view of female genitalia with ovipositor removed.

Sonia comstocki, new species: Fig. 2, left harpe; Fig. 4, ventral view of female genitalia with ovipositor removed.

Sonia comstocki, new species

(Plate 14, Figures 2, 4)

Alar expanse, 20-24 mm.

Labial palpus white suffused with buff and with a brownish shade in the brush of second segment; outwardly on second segment, near apex, a brown spot. Antenna brownish ocherous with buff annulations. Head, thorax, forewing, legs and abdomen whitish to buff suffused and overlaid with ochraceous-buff; costal fold of male about one-third the length of the forewing; from outer end of costal fold, to apex, a series of short, brown, geminate markings; ocelloid patch indicated by an outer crescentic and several inner, irregular, whitish semi-metallic spots and a few scattered dark brown scales; basal patch faintly indicated in the more strongly marked specimens; cilia white with a narrow, dark sub-basal band. Hind wing shining white with a mottling of ocherous and brown scales; cilia white with a narrow brownish ocherous sub-basal band.

MALE GENITALIA. — Harpe as figured. Uncus short, weak, bifurcate. Tegumen truncate, broad. Socii strong, directed ventrad, straight. Vesica with a cluster of many slender cornuti.

FEMALE GENITALIA. — As figured.

TYPE. — U. N. National Museum No. 61471.

TYPE LOCALITY. — San Felipe Wash., San Diego County, California.

REMARKS. — Described from the male type, six male and one female paratypes. All are from the same locality, bear the same date (II. ix. 1938), and were collected by Dr. John A. Comstock.

I take pleasure in naming this species for Dr. Comstock, who has contributed so much to our knowledge of western Lepidoptera.

The genitalia of *comstocki* are almost identical to those of *vovana* but have a smaller clasper and a more sharply defined anal angle of the cucullus. The neck of the harpe is also narrower than that of *vovana*. In the female the anterior edge of ostium is weak and membranous in *comstocki* but sclerotized in *vovana*.

NEW NEOGÆAN WATER-STRIDERS OF THE GENUS MICROVELIA (HEMIPTERA; VELIIDÆ)

By C. J. DRAKE and F. C. HOTTES

Water-striders of the genus *Microvelia* Westwood are found in many different kinds of aquatic habitats, and are particularly at home in tropical and subtropical regions. More than 60 different species have been recorded from the Americas. The present paper contains the descriptions of two new species from Mexico, one from Puerto Rico and two from Argentine. On account of their small size, often two millimeters or less in length, only the commoner and more widely distributed species are usually found in collections. The disposition of the types of the new species is given beneath the description of each species.

Microvelia zillana, sp. new

APTEROUS MALE: Small, rather slender, moderately narrowed posteriorly, brown, without color markings. Pubescence dense, brown.

SIZE: Length, 1.75 mm.; width at base of abdomen, 0.70 mm.

HEAD: Width across eyes, 0.50 mm. Broad, the median line distinct. Eyes large, reddish brown. Antennæ long, rather stout, dark brown, paler at base, pubescent; formula — I, 20; II, 18; III, 25; IV, 25. Rostrum testaceous, dark fuscous apically.

THORAX: Pronotum very large, strongly roundly produced posteriorly, covering rest of dorsal surface of thorax, half as long as broad (26:52), pits present but rather difficult to see, the posterior margin broad and very slowly rounded. Legs moderately long, moderately stout, dark brown with coxæ, trochanters, and bases of femora testaceous; femora only a little enlarged, unarmed, all about equal in thickness. Tarsal segments of both middle and hind legs about equal in length.

ABDOMEN: Moderately narrowed posteriorly; connexiva wide, erect, not produced behind. Venter without protuberances, last two segments flattened and explanate on sides and hind margin, the explanate sides narrowed and rounded posteriorly and then jointly rounded with the explanate margin of last ventrite, which projects over the base of the first genital segment. First genital segment roundly impressed basally and then raised apically.

MACROPTEROUS FEMALE: Length, 2:30 mm.; width, 1.00 mm. Pronotum very large, almost triangularly produced behind, with humeral angles moderately prominent, median longitudinal line distinct, wider across humeral angles than median length (80:60), pits more prominent than in apterous form. Hemelytra dark fuscous with veins a little darker; outer margins fringed with moderately long brownish hairs; last three abdominal segments

strongly narrowed and compressed laterally; last ventrite narrowed with sides almost parallel, nearly as long as two preceding segments, impressed a little behind on each side of median line. Other characters as in male.

TYPE (apterous male) and ALLOTYPE (macropterous female), Mayaguez, Puerto Rico, April 4, 1936, H. D. Tate.

This singular brownish species without color markings may be separated at once from its allies by the structure of the underside of the last two ventrites of the male (thickened, flattened, plate-like, explanate on sides and apex and somewhat semicircular with apex rather sharply rounded). The abruptly constricted and laterally compressed last three abdominal segment distinguishes the female. The peculiar plate-like structure on the apical part of the male venter is not found in any other American *Microvelia*.

Microvelia rasilis Drake

Microvelia rasilis Drake, Proc. Biol. Soc. Wash., 6:77-78. 1951.

Six adults and several nymphs, Puebla, Mex., July 20, 1951, taken near the water's edge under overhanging vegetation in a large sulfur-water pond, fed by large sulfur springs. This was the only water-strider found in the sulfur water and about an hour was spent by the authors finding the specimens. The type series (4 specimens) were taken in a lake near Mexico City.

Microvelia pueblana, sp. new

APTEROUS FORM: Moderately large, black with a transverse band near front margin of pronotum, a small spot on each side of hind margin of pronotum and a spot on each connexival segment brown. Legs mostly testaceous with brownish largely on dorsal surface. Underside of entire body blackish with sides of connexival segment brown. Pubescence short, brownish black. Antennæ dark brown with terminal segment blackish, the first two segments beneath mostly testaceous.

SIZE: Length, 2.40 mm.; width, 0.90 mm.

HEAD: Width across eyes, 0.60 mm. Head convex above, finely transversely rugulose, the median line fairly distinct. Eyes moderately large, brownish. Antennæ moderately long, moderately stout, pubescence interspersed with a few short hairs; segment I stout, slightly bowed, much thicker than II; II much stouter than III, slowly enlarged towards the apex; III very slender; IV distinctly stouter than III; formula — I, 17; II, 13; III, 18; IV, 28. Rostrum yellowish brown with apical part blackish, not reaching to the middle of mesosternum.

THORAX: Pronotum very large, strongly produced posteriorly, covering rest of dorsal surface of thorax, coarsely pitted, with posterior margin slowly broadly rounded, much wider than long

(64:37). Legs moderately stout, moderately long, clothed beneath with brownish hairs, all femora moderately incrassate, unarmed; anterior femora slightly thicker than hind pair; middle femora feebly thicker than hind pair. Second tarsal segment of both middle and hind legs a little longer than first.

ABDOMEN: Narrowed posteriorly beyond the middle; beneath convex, without spines or tubercles; connexiva with outer margin slowly rounded, widest near middle, becoming narrower posteriorly; last ventrite feebly broadly emarginate. Male genital segments small, largely retracted and not exposed. Female and winged forms unknown.

TYPE (male), Puebla, July 29, 1951, collected by the authors. PARATYPE, 1 male, Oaxaca, Mex., July 21, 1951, collected by authors in a small irrigation ditch in a vegetable garden. The paratype lacks the small color marking on hind margin of pronotum and connexival segments; the legs are also darker than in the type. A female from Alvarado, Mex., July 28, 1951, seems to be this species, but on account of the more coarsely pitted pronotum and much larger size, it is not treated as a part of the type series.

M. pueblana differs from *M. verana* n. sp. by its larger size and stouter antennæ. *M. oraria* Drake is a smaller paler species with the last antennal segment very long.

***Microvelia ioana*, sp. new**

APTEROUS FEMALE: Small, robust, brownish with the greater part of the last three abdominal segments and a large spot on each side of the base of the abdomen testaceous; sides of body brownish testaceous with sternum and venter blackish; pronotum tinged with some testaceous.

SIZE: Length, 2.15 mm.; width, 0.85 mm.

HEAD: Width across eyes, 0.62 mm. Head broad, blackish fuscous, the median line distinct, blackish. Eyes blackish. Antennæ moderately long, rather slender, dark brown with basal segment largely testaceous, pubescent, with a few scattered longer hairs; formula — I, 17; II, 15; III, 24; IV, 26.

THORAX: Pronotum very large, widely and almost truncately produced posteriorly, covering all of the rest of the dorsal surface of the thorax, almost rectangular in outline, much wider than long (40:30), with an irregularly arranged transverse row of pits dividing the pronotum into two parts, the hind part larger and coarsely pitted, the front part (save narrow collar) not pitted; constricted on lateral sides just opposite the wavy transverse line formed by pits. Sides of entire body with some long, erect, scattered, dark brown hairs. Legs moderately long, moderately stout, unarmed, the femora slightly thickened and about equal in thickness; tarsal segments about equal in length in both middle and hind legs.

ABDOMEN: Broad, narrowed a little posteriorly, the last ventrite much longer than preceding segment; connexiva broad, margined with brown, strongly reflexed posteriorly; genital segments retracted and very little exposed.

TYPE (female), Rio de Janeiro, Bras., Dec. 6, 1938, C. J. Drake (Drake Collection). Male and winged form unknown.

The shape of posterior margin of pronotum, which extends backwards very broadly with posterior margin subtruncate and only feebly rounded, distinguishes this insect from its allies. Also, the hind part of the pronotum back of the transverse wavy line is distinctly pitted, whereas the narrower front part is impunctate.

***Microvelia verana*, sp. new**

APTEROUS MALE: Small, oblong, narrowed posteriorly, fuscous black with transverse band on front margin of pronotum, a small spot at the base and last tergite of pronotum, and the posterior part of each connexival segment brownish. Legs dark brown with coxæ, trochanters, basal part of femora above, most of underside of fore and middle femora, basal half of hind femora both above and beneath whitish; hind tibiæ with a narrow basal ring and most of apical two thirds whitish. Antennæ dark fuscous-brown with large part of basal segment paler.

SIZE: Length, 1.80 mm.; width, 0.70 mm.

THORAX: Pronotum very large, strongly produced posteriorly so as to cover rest of dorsal surface of thorax, rather coarsely pitted, much wider than long (54:29), the posterior margin slowly broadly rounded. Legs rather long, moderately stout; femora moderately thickened and unarmed, the anterior femora slightly thicker than the other pairs; anterior tibiæ with an apical spur. Second tarsal segment of hind legs slightly longer than first (10:12); tarsal segments of middle legs also nearly equal in length (10:12).

ABDOMEN: Moderately narrowed posteriorly with sides feebly rounded; dorsal surface clothed with very fine, not very long, inconspicuous, dark hairs. Venter without tubercle or spine; last ventrite longer than the preceding segment, feebly and broadly emarginate behind. Last tergite longer than the preceding segment, truncate behind. Genital segments largely retracted and not visible.

TYPE (apterous male), Alvarado, Mex., July 28, 1951, taken by the authors, in a stagnant pool connected on one side with a small permanent stream.

The fine hairs on dorsal surface of abdomen separate this insect from other Mexican species. The antennal formula is — I, 15; II, 11; III, 22; IV, 27. The connexivum has a reddish stripe on each side.

***Microvelia inannana*, sp. new**

APTEROUS FORM: Very small, above brown or brownish fuscous with some irregular areas darkened, oblong and narrowed posteriorly (male) or distinctly ovate (female). Entire body beneath testaceous.

SIZE: Length (male), 1.50 mm., 1.25-1.50 mm. (female); width, 0.54 mm. (male) and 0.50-0.62 mm. (female).

HEAD: Width across eyes, 0.41 mm. Head above convex, brown or fuscous with or without a broad stripe on each side of median line. Eyes moderately large, dark brown, sometimes reddish. Antennæ moderately stout, rather long, dark brownish, paler at base, pubescent; formula — I, 9; II, 7; III, 10; IV, 15. Rostrum testaceous, darkened apically, not attaining middle of mesosternum.

THORAX: Pronotum (male) moderately large, produced posteriorly so as to conceal about half of mesonotum, the posterior margin almost truncate (feebly concave); mesonotum with exposed part about half as long as pronotum. Pronotum (female) short, scarcely if at all produced posteriorly. Legs rather short, moderately stout, testaceous with posterior part of femora, the tibiae and tarsi brown or fuscous; fore and hind femora a little stouter than middle pair; femora unarmed; hind tarsi straight in male.

ABDOMEN: Distinctly narrowed posteriorly in male and more ovate in female; connexiva wider in female than male, not reflexed in either sex. Sometimes the last three tergites as well as the median part of metanotum and base of abdomen brownish. First genital segment in male deeply roundly emarginate behind, above broad and truncate on hind margin.

TYPE (male), **ALLOTYPE** (female) and 6 female **PARATYPES**, Tigre, Buenos Aires, Arg., Dec. 10 and Nov. 20, 1938, C. J. Drake (Drake Collection). Winged form unknown.

This tiny species belongs to the *M. robusta* Uhler group of species, but is distinctly smaller, and paler in color, with shorter legs, straight hind tarsi in male and different antennal formula. The hind tibiae in male of *M. robusta*, *M. puchella* Uhler and *M. borealis* Bueno are distinctly curved in the male.

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**NOTES ON THE GENUS *GLENA* HULST AND
DESCRIPTIONS OF NEW SPECIES**

Lepidoptera, Geometridae

By JOHN L. SPERRY, Riverside, California

In 1874, 6th Report Peabody Acad. Sci., 51, Packard described a Cleorid species from Texas (Belfrage) naming it *quinquelinearia* and placing it in the genus *Cymatophora* Hubner. This species, not too common in collections, has given trouble to the systematists ever since.

Several years ago the author received, from North Texas, two males which proved, on comparison with the type in the Museum of Comparative Zoology, to be this species. Since my friend, Mr. L. H. Bridwell, who furnished the specimens, has gone to his reward and it seems unlikely that more material will be available to the author from that vicinity, the author feels that it may be worth while to discuss a part of the genus *Glena* and clarify the situation insofar as his knowledge allows. To this end the author has made bold to ask his friends for the loan of material and here wishes to thank Mr. Carl W. Kirkwood of Summerland, Calif., Dr. J. F. Gates Clarke of the National Museum, Dr. Eugene Munroe of the Canadian National Museum, Dr. Frederick H. Rindge of the American Museum of Natural History, Rev. Edward Guedet and Dr. Edward S. Ross of the California Academy of Sciences, Mr. Lloyd Martin of the Los Angeles County Museum, Mr. Chester A. Thomas of Zion and Bryce National Parks and my good friend Mr. Louis Schellbach of Grand Canyon National Park for their kindness in the loan of specimens and slides which has made this study profitable.

Among the specimens before the author there are five separate groups, three of which are certainly species, the other two being very close to *quinquelinearia*, separable certainly, but having genitalia which are almost identical. It is possible that *interpunctata* B. & McD. and the smaller form from the Santa Rita Mts. are environmental forms of *quinquelinearia*, however without definite proof it becomes a matter of personal opinion and the author has always hesitated to place close relatives in the same species without definite proof that there they belong. To do so would be to state, in substance that these rather readily separable insects will mate freely, the Texas population with the Arizona, that the females will lay fertile eggs and that the imagos resultant from the cross matings will be fertile. The author does not have sufficient information to make this statement and prefers to separate the insects until breeding experiments may prove the

separation erroneous, on the assumption, purely a personal opinion, that a larger number of separable species makes for less confusion than a smaller number of variable species determinable only by dissection, although it really makes little difference whether complete information changes a listed form to a species or a species to a form.

Glena quinquelinearia Packard

The author will not repeat the catalog names, this was done in an entirely satisfactory manner by McDunnough (Studies in N. Am. Cleorini, Bull. 18, Ent. Branch, Dept. of Agriculture, Dom. of Canada, 1920) suffice it to say that the drawing in Packard's Monograph is good, that the photograph in the B. & McD. Contributions III, (4) Pl. XXV Fig. 8 and the genitalia P. XXX fig. 4 do not represent this species, as noted by McDunnough (Can. Ent. LXXVII.66). Packard's description is good, the ground color is white but the species seems dark because of the heavy shading bands basad of the t.a. line and distad of the t.p. on the primaries; the females are lighter than the males. It is a small species with an average expanse of 25 mm. The habitat is central Texas.

Glena interpunctata B. & McD.

This species is separable from *quinquelinearia* by the even, smoky-gray ground color of the wings and the lack of the black and white banding dorsally on the abdominal segments; there is little shading along the lines or in the subterminal areas of the wings, the discal spots are usually but not always absent or greatly reduced. There is a constant though slight genitalic difference which will be mentioned later. It is a larger insect than *quinquelinearia* expanding from 30 to 32 mm. The habitat is the south-eastern part of Arizona.

Glena kirkwoodaria var. n

In the Santa Rita Mts. of Southern Arizona flies another member of the group; it is probably a variety of *interpunctata*, differing in its smaller size (25-26 mm) the darker, slate-gray ground color, the straighter lines with the median merely indicated or wanting entirely and the presence of distinct discal dots on both wings.

Holotype ♂ Madera Canyon, Santa Rita Mts., Arizona Aug. 2, 1947, Comstock and Martin collectors and in the Sperry Collection.

Allotype ♀ same locality and collectors, July 19, 1947 and in the Los Angeles County Museum.

Paratypes 4 females same locality and collectors, July 20 to 25, 1947, May 7, 1948 and Aug. 29, 1950 Hill; 1 ♀ N. of Payson, Ariz. 7.24.51, Henne and 1 ♀ Madera Canyon, Ariz. Kirkwood & Ried, July 15, 1951 and in the collections Henne, Kirkwood and Sperry.

It gives me pleasure to name this fine insect in honor of my friend Carl W. Kirkwood, of Summerland, California, able collector and student of the Lepidoptera, with a consuming desire to know more and yet more about the insects which he studies. May he have many years of fruitful work with the insects of the southwest.

***Glena mcdunnougharia* sp. n**

This is the species pictured by Barnes & McDunnough, 1917, Contributions to Nat. Hist. Lep. III (4) Pl. XXV f. 8, but not the genitalia Pl. XXX f. 4; the photograph is excellent and but little can be added in way of description.

Palpi are short, fuscous; front brown with a gray streak low on the face; vertex and antennal shaft white; pectinations light tan from a dark base; collar dark fuscous; thorax white with fleckings of gray; abdomen gray-white, banded distally on each segment with a narrow black band edged with white.

Legs light tan. Ground color of the wings white, t.a. line distinct, from $\frac{1}{4}$ out on inner margin goes diagonally outward to the cell where it disappears, median line light from $\frac{1}{2}$ paralleling the t.p. line to vein 5; t.p. line heavy, from $\frac{1}{2}$ out diagonally to vein 6 thence curving sharply back to costa, from vein 6 to costa merely indicated, sometimes wanting. Shading of the t.a. line basad and the t.p. line distad is a light tan brown. There is an irregular s.t. shade turning outward between veins 6 and 7 and deepening into a distinct dash at the outer margin. Terminal line distinct, continuous, fringes gray-white with a median, darker shade. Discal dots usually not present or minute, occasionally strong.

Secondaries have t.a. line broad, diffuse, from .4 out on inner margin straight to median fold; t.p. line curving slightly outward to vein 6 starting $\frac{2}{3}$ out on inner margin. Shadings are, a light fuscous, following t.p. line, a darker subterminal and lighter terminal shade. Terminal line, fringes and discal dots as in primaries. Beneath both wings unicolorous light gray. Expanse ♂ 29 mm. ♀ 32. mm.

Holotype ♂ Granite Wells, San Bernardino Co., California May 24, 1939 Grace H. and John L. Sperry collectors and in the Sperry Collection.

Allotype ♀ Same locality and collectors May 25, 1939 and in the Sperry collection.

Paratypes 18 ♂, same data May 24 and 25, 1939; 1 ♂ Todd's Lodge, Oak Creek Canyon, Arizona, June 12, 1941, Grace H. and John L. Sperry; 1 ♀ same data June 15, 1942; 1 ♀ Peach Springs, Arizona, May 29, 1934, Grace H. and John L. Sperry; 1 ♀ Bryce Canyon, Utah, July 19, 1949, C. A. Thomas, coll.; 1 ♀ South Rim, Grand Canyon, Ariz., June 16, 1941, Louis Schellbach, coll.; 2 ♂ Ibanpah Mts., Calif., April 29, 1939; 1 ♂ Dividend, Utah, July 1,

Tom Spalding; 1 ♂ White Mts., Ariz., May 25, 1934; 1 ♂ Gila-Pinal Co. line, Ariz., June 15-20, 1925, O. C. Poling, 1 ♂ 50 mi. N. of Eureka, Nev., June 21, 1934, J. A. Comstock, 2 ♂ 1 ♀ Grace H. and John L. Sperry, from Granite Wells, Calif., May 25, 1939, Dennison, Ariz., May 28, 1934, and Fairview, Ariz., July 3, 1935; 1 ♂ Cajon Pass, Calif., Apr. 20, 1939, Guedet; 1 ♂ Grand Canyon, Ariz., July, 1931, R. Williamson and 2 ♂ South Rim of same, June 14 and 19, 1941, Louis Schellbach and in the Grand Canyon Museum collection; also the following specimens in the National Museum collection, 1 ♂ Bellevue, Wash. Co., Utah, 25-6-17, 1 ♀ same data, July 10, 1917; 1 ♂, 1 ♀ Paradise, Cochise Co., Ariz., May 8-30, coll. Barnes; 3 ♂ Glenwood Springs, Colo., June 16-30; 2, ♂, 1 ♀ Jemez Springs, N. M., June, 1916, coll. Barnes and 1 ♂ Stockton, Utah, 6-6-1913, Tom Spalding; 2 ♂ Eureka, Utah, June 12-14, 1909, Tom Spalding.

These are in the collections of the National Museum, American Museum of Natural History, Los Angeles County Museum, California Academy of Sciences, Canadian National Museum, British Museum, French National Museum, Grand Canyon Park Museum, Bryce Canyon Museum and collection Sperry.

The best distinguishing characters of this species are the continuous terminal line and the white expanse of the wings.

Since Dr. McDunnough has done most of the preliminary work in this group of the Geometridae it seems fitting that this species, the finest of the Glenas, should bear his name. It gives me fond pleasure to name this beautiful insect for one more largely responsible for our present knowledge of the North American Geometridae than is any other entomologist, our guide upon the labyrinthine paths of this difficult family and counselor when the way becomes hard, my friend Jim.

***Glena thomasaria* sp. n.**

There is still another member of this group found through northern Arizona and New Mexico and southern Utah. The size, ground color and arrangement of the lines of the wings are nearly as in the preceding species with the following distinct differences: the median line on the primaries starts at the inner margin touching the t.p. line, diverges slightly as it crosses the wing to the cell, thence turns sharply away from the t.p. line to the costa. This line is heavier than in any other member of the group, being about as dark and wide as the t.p. line, with which it makes a narrow, irregular V.

On the secondaries the t.a. line is distinct and broad, curving evenly from inner margin almost to costa. The terminal line is made up of dots between the veins from 2 to 7. Discal dot wanting or lost in the median line of primaries wanting or minute in

secondaries. Fringes white. The male genitalia are pictured in the Barnes & McDunnough Contributions, 1917, Vol. III, No. 4 Pl. XXX, fig. 4.

Holotype ♂ South Fork of Little Colorado River, White Mts., Ariz., June 25, 1947, Grace H. and John L. Sperry, collectors, and in the Sperry collection.

Allotype ♀ Chavez, N. M., July 2, 1935, Grace H. and John L. Sperry, collectors, and in the Sperry collection.

Paratypes, 1 ♂ same collectors, South Fork of Little Colorado River, Ariz., June 25, 1947; 3 ♂ Vernon, Apache Co., Ariz., July, 1936, Guedet Coll.; 1 ♂ Grand Canyon, Ariz., July, 1931, R. Williamson, coll.; 1 ♂ N. Rim of same, July 12, 1939, Schellbach; 1 ♂ Simpson's Ranch, 5 miles east of La Jara, Sandoval Co., New Mexico, July 20, 1950, T. Cohn, P. Boone and M. Cazier; 2 ♀ Bryce Canyon, Utah, July 14, 1949, C. A. Thomas, coll.; 2 ♀ South Fork of Little Colorado River, White Mts., Ariz., June 20-25, 1947, Grace H. and John L. Sperry, collectors. These are in the U. S. National Museum, Am. Museum of Nat. History, Canadian National Museum, Los Angeles County Museum, California Acad. of Sciences, Bryce and Grand Canyon Museums and collection Sperry.

It gives me great pleasure to name this interesting species in honor of Mr. Chester A. Thomas of Zion and Bryce National Parks, an excellent entomologist in his own right and a friend of long standing to Grace and the author, he has done much to further the knowledge of the New Mexican and Southern Utah Geometridae.

This completes the *quinquelinearia* complex as represented in the author's collection, although there are at least two South American species which undoubtedly belong in this genus. There is yet another species which, coming from North Texas and resembling *pexata* Swett belongs in the genus.

Glena minor sp. n.

Palpi short, $1\frac{1}{2}$ times the diameter of the eye, dark fuscous brown, flecked with white at the tips, thin scaled. Front black-brown with white line low on the face, antennae fuscous, the pectinations black at the base, vertex, collar, thorax white, flecked with fuscous scales, abdomen same, with dorsal fuscous bands distally on each segment. Legs outwardly dark gray-brown, inwardly creamy white. The male hind tibia is swollen, with strong hair pencil. Both wings are heavily irrorate with fuscous gray atoms, gathered into shade bands beyond the t.p. lines.

Primaries: there are three broken indefinite lines starting at black spots on the costa. T. a. line from $\frac{1}{4}$ out goes at right angles to costa to cell, thence curving back past the outer edge of the fovea in the ♂ to inner margin $\frac{1}{5}$ out. Median line merely indicated by the largest costal spot at nearly $\frac{1}{2}$, a spot at junction of

cell and vein 2 and a diffuse line from cell to inner margin at $\frac{2}{3}$. T.p. line from spot on costa at $\frac{2}{3}$ weak or nearly wanting except on the veins where it is distinctly toothed outwardly, subparallel to outer margin goes to inner margin at $\frac{2}{3}$; three irregular shade bands in subterminal area, darkest opposite the cell, no lines evident; tiny terminal spots between the veins from 1 to 8 in δ , in η these spots are heavy. Fringe gray, discal dash obscure, in median line.

Secondaries: t.a. line a broad, irregular curved band from $\frac{1}{3}$ on costa to $\frac{1}{3}$ out on inner margin; t.p. better developed than on primaries, heavily toothed on the veins, subparallel to outer margin $\frac{2}{3}$ out, the three subterminal shades also are heavier than on primaries as are also the terminal triangular dots between the veins. Fringe as in primaries. Discal spot distinct.

Beneath fuscous gray, with discal spots evident, secondaries lighter than primaries. Expanse δ 27 to 30 mm. female 28 mm. to 30 mm.

Holotype δ Montague Co., Texas, May 12, 1941, L. H. Bridwell, coll. and in the Sperry collection.

Allotype η same locality and collector, Sept. 30, 1940 and in the Sperry collection.

Paratypes 1 δ Forestburg, Texas, July 15, 1941, L. H. Bridwell coll. 1 η same data, Aug. 20, 1941; 1 η Montague Co., Tex., June 22, 1940; 1 η Montague Co., Tex., Aug. 28, 1940, all collected by L. H. Bridwell. 1 δ Hinton, Okla., July 25, 1937, Standish-Kaiser; 1 η Montague Co., Tex., Aug. 28, 1940, L. H. Bridwell, in the U. S. and Canadian National Museums.

This species is probably closest to *pexata* Swett. It is considerably smaller and much more heavily shaded. The ground color of the wings is darker both above and below. The η genitalia separate the species readily.

It gives me great pleasure to name this fine *Glena* in honor and in fond memory of my friend, Arthur Jacob Minor, 1886-1950, student of the natural sciences, philosopher, mathematician without a peer and friend to all the little creatures of the woods and fields. Probably my best friends, he has gone to his reward and in passing has left to me, until death do us part, his dearest treasure.

The δ genitalia in the *quinquelinearia* group are relatively simple, the uncus is short, hollow, truncated, with the edges seeming to form a notch. The tegumen is broad, the costal arm of the valve is finger-like, curved and covered, for over $\frac{2}{3}$ of its length from apex to base, with stiff, colorless bristles. The sacculus is produced in a flat, chitinized pencil to nearly the length of the costal finger, the tip swollen roughly spoon shaped and armed with dark curved spines. The aedeagus is short and blunt, rather broad and straight and the vesica is armed with a brush of many fine short bristles and a long heavy, hollow spine, curved back

upon itself at the open base. This latter part of the organ is deciduous and so not too useful as a diagnostic character.

In *quinquelinearia* the arm of the sacculus reaches about $\frac{3}{4}$ of the way to the tip of the costal finger, the spoon-like sacculus tip is heavily armed with perhaps 20 long, dark, curved spines curving to a point at the apex; the gnathos is equilaterally triangular, toothed on the rounded edge with tiny cornuti and roughened dorsally. The base of the costa makes a chitinous point where the transtilla joins. The brush of spines on the vesica are heavy and dark.

In *interpunctata* B. and McD. the sacculus arm reaches to within $\frac{1}{2}$ of the way to the tip of the costal finger, the spoon-like end is armed with about twice the number of spines which are much shorter than those of the preceding species. The gnathos is narrower with a dorsal ridge, the costa runs smoothly into the transtilla and the brush of bristles on the vesica is weak.

In *kirkwoodaria* sp. n. the brush of bristles on the vesica is heavier than in *interpunctata* otherwise the δ genitalia is much like *interpunctata*.

In *thomasaria* sp. n. the whole organ is more heavily chitinized and narrower than the others and the sacculus arm is heavily spined for most of its length. This is pictured in the B. and McD. contributions, III (4) Pl. XXX f. 4.

The η genitalia are similar with reasonably good separating characteristics throughout this group. In *quinquelinearia* the 8th segment is sclerotized, the ostium almost membranous, ductus bursae short, tripling in width dorsally as it enters the bursa, thence slightly expanding for a distance of about 7 times this diameter, thence angling ventrally and expanding into the bursa proper.

The organ looks exactly like a sock with heel and toe inflated, the signum in the heel. The ductus seminalis is small, rising ventrally from the bursa close to the junction with the ductus bursae. In *quinquelinearia* the 8th segment has two narrow, smooth edged, ribbon-like patches of darker schlerotization, the ostium's semicircular plate is so weak it is scarcely discernible, the signum is a heavy, half-moon shaped, chitinous pocket, heavily spined inwardly, with perhaps 18 spines. The sock leg is broad and the foot long.

In *interpunctata* the 8th segment is heavily chitinized, the ribbon is broader and the edges thereof irregular, the signum is more heavily spined with from 23 to 25 spines, the sock leg is narrowed below the ductus bursae and the foot is short with the toe shrunk well back toward the instep.

In *kirkwoodaria* the ostium is membranous, the signum narrower but still heavy, otherwise as in *interpunctata*.

In *mcduffnougharia* the 8th segment is lightly chitinized, the ostium membranous, the signum very short, rectangular and

chunky with a few heavy spines, perhaps 8 or 10, the sock has a well developed heel and an extended toe, the leg is narrow.

In *thomasaria* the 8th segment has two broad, ovate chitinous patches, the ostium is membranous, the ductus likewise and short, the bursa expanding rapidly below into an ovate organ with no trace of the sock shape. The signum is large and heavy, with long spines, the ductus seminalis rises ventrally from the bursa copulatrix, far removed from the ductus bursae and is large, at least five times the diameter of the other members of the group.

In the case of *pexata* and *minor* the author is not fortunate enough to possess a ♂ specimen of *pexata* which seems to be rather a rare specimen in collections, however, from the photograph in McDunnough's studies in N. Am. Cleoriinae Pl. III f. 11 it would seem that in *minor* the sacculus arm is longer and more heavily spined both at tip and centrally, that the aedeagus in *minor* is narrower and the long spine which is bent back upon itself is about twice as long and heavy in *pexata* as it is in *minor*. In the female genitalia there are, on either side of the vaginal opening, sack-like organs, in *pexata* oval and heavily and darkly chitinized inwardly, in *minor* these are elongate and lightly chitinized. In *pexata* the signum is heavily spined, large and almost circular, in *minor* this organ is narrow, much smaller, shaped like a peach stone and heavily spined.

GLENA, Hulst



quinquelinearia, Pack.



interpunctata, B. & McD.



mcdunnougharia, sp. n.



kirkwoodaria, var. n.



thomasaria, sp. n.



minor, sp. n.



Plate 15

All figures approximately $\frac{2}{3}$ natural size

DURAL BLOOD VESSELS OF SALAMANDERS

By WILLIAM A. HILTON

(Department of Zoology, Pomona College)

Gaupp '99 distinguishes three brain membranes in the Frog:

1. An outer periosteal or parietal dura closely applied to the bony walls inclosing brain and spinal cord.
2. A strong fibrous membrane, the "visceral dura" separated from the former by an interdural space with the endolymphatic sacs, hypophysis and part of the paraphysis within this space.
3. The pia-arachnoid which is closely applied to the brain and spinal cord and bearing many blood vessels.

One of the earliest papers on the meninges and their blood vessels in salamanders was by Rex '92 on Triton and Salamandra. Gage '93, in the brain of *Diemyctylus* (*Triturus*) *viridescens* speaks of three brain membranes, the pia, arachnoid and dura. The last lines the cranial cavity and sends off—"an almost complete investment for the supraplexus, a somewhat partial one for the hypophysis; filling a large space caudad of the more spongy part of the metaplexus; surrounding the protrusion of the endolymphatic sacs into the cranial cavity and surrounding their ganglia." According to Gage the grosser vascular supply to the brain of Triton as given by Rex '92, agrees with *Diemyctylus*.

The meninges of *Necturus* according to Kingsbury '95 and *Ambystoma* according to Herrick '35 are much as described by Gage. O'Neill '98, describes two membranes in *Salamandra*, a dura mater in two layers and a primary vascular coat. The dura on the outside is largely a tough connective tissue membrane which splits in a few places to form two layers surrounding interdural spaces. The outer layer next the bones of skull and spinal cord is the periosteal layer, the inner nearer to the brain is the neural layer. The inner or primary vascular coat with its blood vessels corresponds to the pia as usually described. Sterzi '01 in *Salamandra* and Molge recognizes a periosteal membrane and a meninx primitiva, with no differentiation of dura. In *Ambystoma* Herrick '35 and '48 describes a well-defined pachymeninx externally of the much more delicate pia-arachnoid. He follows Kappers '25, who applies the word "dura" only to the inner visceral or neural dura of Gaup. This membrane, as Herrick found for *Ambystoma* is unevenly developed over parts of the central nervous system of salamanders. It quite completely covers the endolymphatic sacs, nodus vasculosus and hypophysis. Apparently the only connection with the outer or peritoneal membrane is where the space is bridged by nerve roots or blood vessels. This inner dura is frequently joined to the arachnoid-pia by connective tissue strands. The spinal cord is also usually quite definitely inclosed in a tough dural membrane. Sometimes this is closely applied to the pia, in others it loosely incloses it—a condition which may be partly due to differences of preparation, but not all.

In a general study of the vascular supply to the brains of tailed Amphibia, it was found that the superficial or dural vessels were frequently either not seen at all or poorly demonstrated. Injected preparations often left them unaffected or only partially shown. So erratic was the appearance of these superficial vessels of brain and spinal cord that one might almost conclude that there was great individual variation. To some degree this is true but much of the differences encountered are due to incomplete injections and the ease with which these outer membranes may be injured in dissections. Often times natural injections gave a clearer picture than any other. It was found also that certain forms had many blood vessels outlined with dark pigment, sometimes the arteries were sharply outlined at other times the veins.

Most salamanders are largely nocturnal in their habits and usually in these which avoid the light but little pigment is developed in the walls of the blood vessels. Some members of the genus *Ambystoma* seem less nocturnal than many—especially *A. longidactylum* where even the internal arteries are well pigmented and easily followed. *Triturus*, especially the eastern form *T. viridescens* is more diurnal. In it the dural vessels, especially the veins, are well outlined.

The two cerebral hemispheres are both inclosed in a common sheath of the inner dural membrane which in most parts of brain and cord are only lightly connected with the pia beneath. At several places the membranes and blood vessels are in close association — at the nodus vasculosus and in the dorsal region of the fourth ventricle. At other places a few small vessels run from one level of membrane to another — probably a few arteries of small

INDEX TO FIGURES

NV—nodus vasculosus, SO—sinus obliquus, JS—jugular sinus.

Plate 16. Brain of *Triturus torosus*. 1. ventral view. 2. dorsal view. Dural vessels shown, network of the nodus vasculosus and sacculus endolymphaticus and plexus of the fourth ventricle somewhat diagrammatic. With the exception of these areas no vessels are shown but those of the true or inner layer of the dura.

Plate 17. 1. Brain of *Triturus viridescens* from below showing dural vessels. 2. Brain of *T. viridescens* from above showing only dural vessels except at the nodus vasculosus and region of the sacculus endolymphaticus and region of the fourth ventricle. 3. A part of the spinal cord of *Salamandra*, dorsal side. The central dark line is a vessel in the deeper membranes, the rest are dural vessels. 4. A part of the spinal cord of *Salamandra*, ventral view showing large lateral dural veins and central deeper artery.

Plate 18. 1. Dural vessels on the dorsal side of the cerebral hemispheres of *Cryptobranchus*. 2. Superficial dural or periosteal vessels at the junction of vertebrae. 3. Periosteal dural layer of blood vessels in the region of two adjacent vertebrae. A view looking down upon the floor of the vertebral cavity after removal of the spinal cord. 4. Similar view as the last at the base of the brain showing blood vessels in the periosteal layer of the dura.

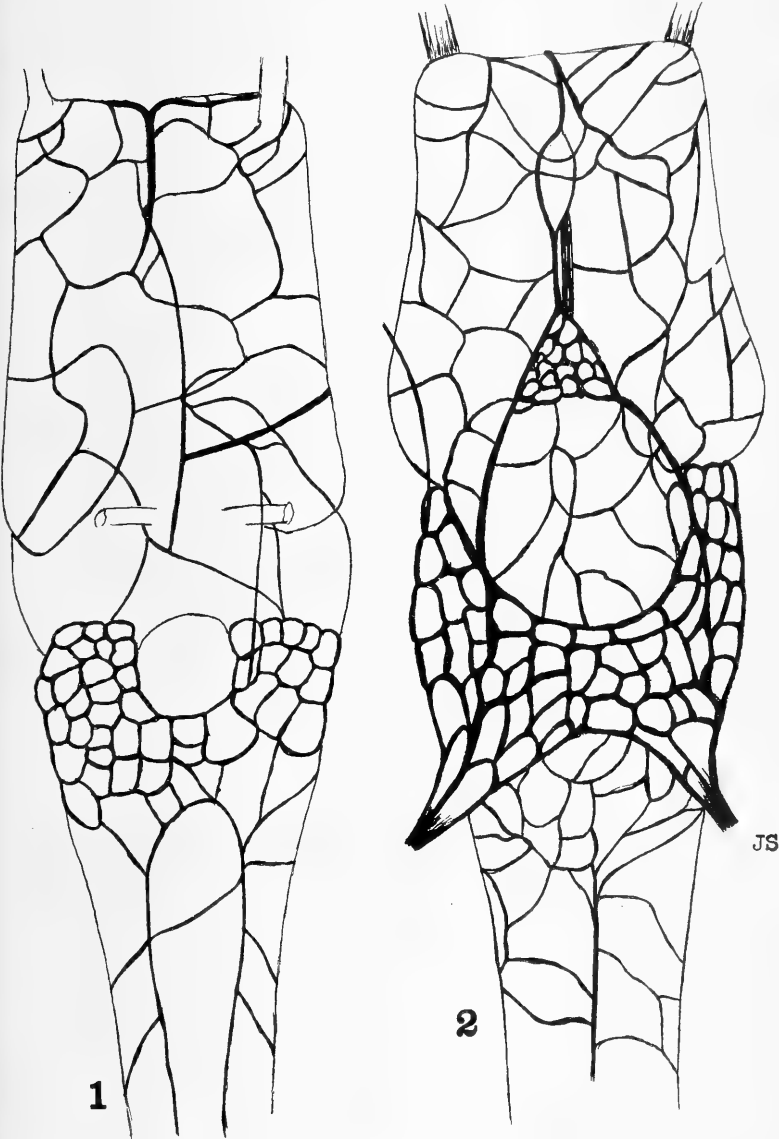


Plate 16

size enter the dura from both the pia and from the peritoneal or outer layer of the pia. Most of the larger vessels which break up into coarse networks in the dura are veins. One or several large veins from the coarse network on the ventral side of the brain pass about to the dorsal side and enter the cephalic end of the nodus vasculosus. From here the blood reaches the region of the fourth ventricle to leave the skull by way of the jugular sinus on each side. Small veins enter the chorioid plexus of the fourth ventricle from the medulla and spinal cord not usually by any large vessels of the dura but from a coarse network. Plate 16; 1 and 2. Plate 17; 1 and 2. Plate 18; 1.

Ventrally in some but not in all, parallel veins near the ventral margin of the spinal cord pass towards the medulla. Plate 17; 3, 4. These larger vessels so well marked in *Triturus* and *Salamandra* are apparently not found in all salamanders. They are connected to the chorioid plexus of the fourth ventricle by a few small vessels but most of the blood from these many channels leaves the spinal cord by way of paired almost segmental vessels. The dorsal side of the spinal cord may or may not have a few large veins near the middle line, but many have merely a network of rather small vessels, or segmental extensions from below.

Roofe '35, In *Ambystoma* speaks of the drainage of the dura from the spinal cord as chiefly into a ventral spinal vein — a condition which I have found in some but not in all. In the region of the hypothalamus there are long anastomosing vessels between the veins of the hemispheres and the plexus of the fourth ventricle. According to Roofe in the dura, ventral to the hemispheres many small irregular anastomosing loops are drained by laterally placed veins which run to the lateral processes of the saccus vasculosus. He also mentions three medially placed veins which run from the forward ventral surface of the dura in the region of the cerebral hemispheres. Similar veins to these I have found to be quite variable. A usual pattern was; one or several large veins which enter the nodus vasculosus, along with deeper ones. These large superficial channels receive numerous branches from both the dorsal and the ventral sides of the cerebral hemispheres. The nodus vasculosus by this means receives more blood than the sinus obliquus or the saccus endolymphaticus.

The outer dural layer or so-called periosteal membrane has an irregular network of blood vessels which are only slightly related to the inner dural. In the dorsal spinal cord area these networks may be especially developed at the junctions of vertebrae, the arteries which supply the region coming from outside the vertebrae. On the ventral side are extensive irregular networks, these become especially marked under the base of the brain. Plate 18; 2-4.

SOME CONCLUSIONS

1. It seems that Gaup's suggestion of two layers of the dura in amphibians is a valuable one, the outer being a periosteal membrane, the inner a dense fibrous coat which may be quite vascular.

2. The development of these two layers apparently is different in different forms, but the outer or periosteal layer is quite distinct from the other both in form and position and probably in function; the inner or true dura is related to the brain, the outer to the bones.

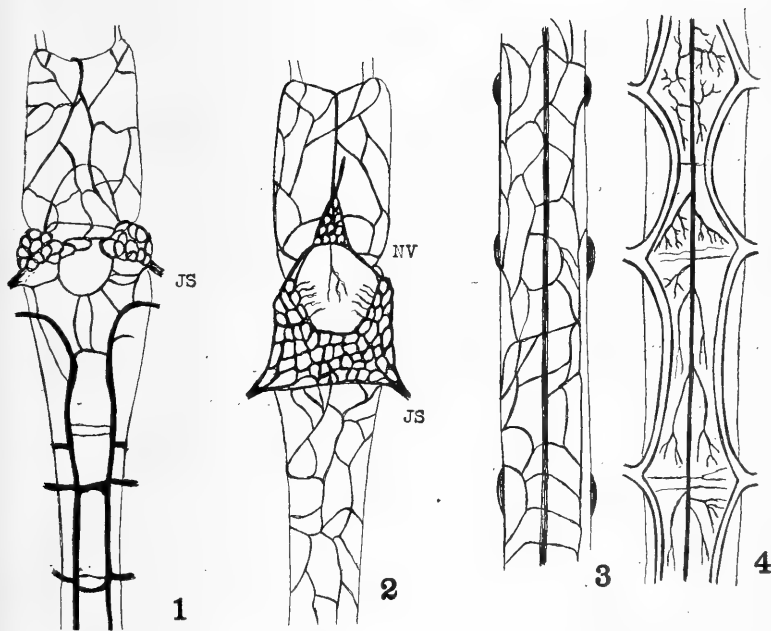


Plate 17

3. The general form of the dural vessels differs greatly but a common appearance is to have one or two strong veins draining both dorsal and ventral sides of the cephalic portion of the brain into the nodus vasculosus.

4. The deep or true dural vessels of the spinal cord may concentrate into a median vessel in some cases or there may be parallel ventro-lateral vessels which run the length of the chord with almost segmental exits along the spinal cord. In any case much of the venous blood passes forward to join that of the sinus jugularis.

5. The arterial supply to the inner or true dura is not marked.

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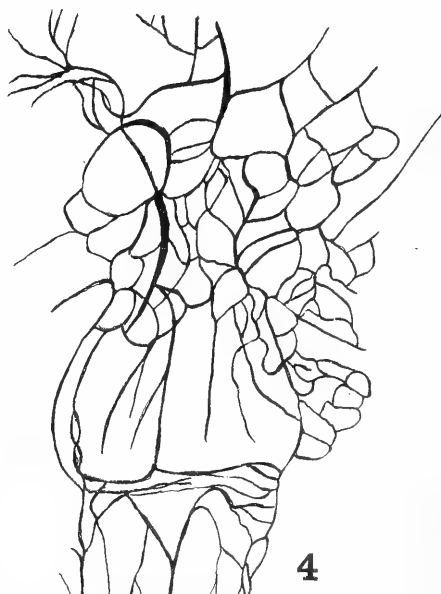
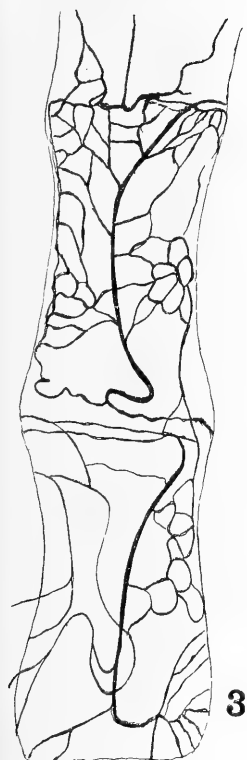
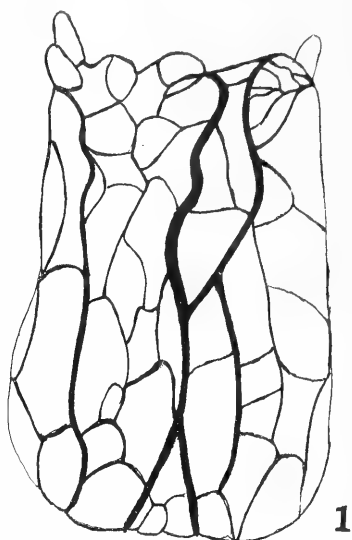
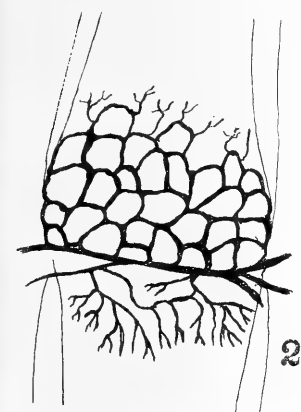


Plate 18

A KEY TO NEVADA FISHES

By IRA LA RIVERS

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The following pages represent the fourth revision of a key to the fishes of Nevada which the author first used for a class several years ago. Few publications, taxonomic or otherwise, exist which are concerned with the Nevada fauna, although the fishes of many adjacent regions such as California, Utah and the Pacific Northwest have been comparatively well worked out. At the time the first draft of the key was laid out, few specimens existed in the University Biology museum with which to work, and heavy reliance was placed on the pertinent literature. Certain publications have been indispensable in keying out Great Basin species: Schultz, 1936 (Pacific Northwest); Hubbs, Hubbs & Miller, and Miller, 1932-present (Nevada); Tanner, 1936-present (Utah, Nevada); and Curtis, 1949, Murphy, 1941, and Neale, 1931 (California) are the most important of the available recent papers in any consideration of the Nevada fish fauna. The definitive work of Hubbs and Miller has been a greater contribution toward our knowledge of the fishes of Nevada than any other single concerted effort, and it is mainly through their activities that we now know the fauna of the State so comparatively well.

In contrast to the recent poverty of the University Biology museum in terms of Nevada fish specimens, some beginning has been made toward a representative collection in the past three years; largely through the efforts of Mr. Thomas J. Trelease, Jr., chief of the Nevada Fish and Game Commission's Division of Fisheries, and those of numerous University students, it is now possible to find nearly every recorded Nevada species of fish in the University collection.

The difficult and controversial problems involved in attempts to stabilize common names of fishes will again be evident in some of the names used in this paper. The recent checklist of Nevada fishes (La Rivers & Trelease, 1952) was the first concerted attempt to establish an official list of names for the State, but it was recognized at the time that some of the names used were not appropriate or satisfactory for certain reasons. "Bonytail" is obviously not a good designation for a genus in which some of the forms have a pencil-shaped caudal peduncle (= "bonytail") while others possess a short, thick caudal peduncle. In other cases, the current desire to apply common names to subspecific entities often results in such an involved and cumbersome terminology that nothing but verbiage is achieved. Accordingly, some changes in the common names will be noted over those employed in the Nevada

checklist, and attempts to name many of the subspecies have been abandoned.

Special thanks are due Dr. Robert R. Miller of the University of Michigan for looking over and annotating the second and third mimeographed drafts of the key and suggesting numerous improvements and additions from his considerable experience with, and knowledge of, Nevada fishes. Whatever inaccuracies that remain are attributable solely to the author.

KEY TO NEVADA FISHES

- Pelvic fins thoracic or jugular in position (i.e., moved forward from their usual position near the anal fin), always present, typically with 1 spinous and 5 soft rays each (reduced to 1 spinous and from 3 to 4 soft rays in Cottidæ); anterior rays of dorsal fin spinous.....1
- Pelvic fins abdominal in position, lacking entirely in some of the Cyprinodontidæ; no spinous rays in fins, except in catfish and introduced carp and goldfish.....10
1. Body lacking true scales, often covered with prickles (Order Scleroperodea, Family COTTIDÆ; Lahontan, Columbia and Bonneville drainage systems); one species, the Smooth Sculpin, with two Nevada subspecies.....2
(*Cottus bairdi* Girard 1850).....2
- Body uniformly covered with scales (Order Percomorphodea, Families PERCIDÆ and CENTRARCHIDÆ; all introduced, mostly from the eastern United States); eight species3
- 2(1). No spines (at most, only a tubercle or two) below single spine at preöpercular angle (Lahontan and Columbia systems)
*Cottus bairdi beldingi* Eigenmann & Eigenmann 1891
- One or two spines below the single spine at preöpercular angle (Bonneville system).....
*Cottus bairdi semiscaber* (Cope) 1871
- 3(1). Two dorsal fins present (Family PERCIDÆ; introduced into the West originally from the eastern U. S.); the Yellow Perch.....*Perca flavescens* (Mitchill) 1814
- Only one dorsal fin present (in *Micropterus*, the Blackbass, the dorsal fin has a deep-to-moderate notch between the anterior spinous and the posterior soft portions) (Family CENTRARCHIDÆ; all introduced); seven species4
- 4(3). Anal fin spines 5 or more in number (Crappie and Sacramento Perch)5
- Anal fin spines 3 in number (Blackbass and Sunfish)....7

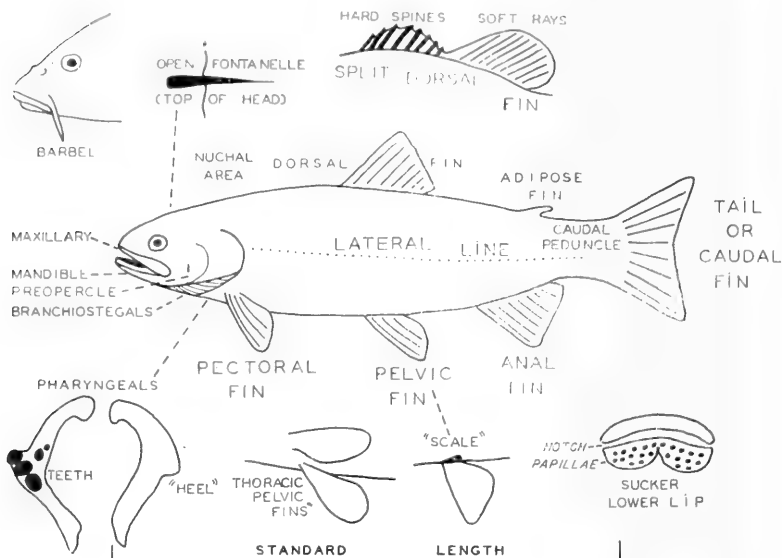


Plate 19

- 5(4). Dorsal fin spines 12 to 13 in number; dorsal fin base much longer than anal fin base; gillrakers short (introduced from California); the Sacramento Perch.....*Archoplites interruptus* (Girard) 1854
- Dorsal fin spines 6-8; dorsal fin base subequal to anal fin base (i.e., both about the same length); gillrakers long and slender (introduced into the West from the eastern U. S.); two species of Crappie (Genus *Pomoxis*).....6
- 6(5). Length of dorsal fin base about equal to distance from origin of dorsal fin (front end) to the eye; dorsal fin spines usually 7 to 8 in number; mandible shorter than pectoral fin; maxillary (including supramaxillary) shorter, reaching posteriorly to about a vertical line from posterior edge of eye pupil; body speckled; the Black Crappie.....*Pomoxis nigromaculatus* (LeSueur) 1829
- Length of dorsal fin base much less than distance from origin of dorsal fin to eye; dorsal fin spines usually 6 in number; mandible about equal in length to pectoral fin; maxillary (including supramaxillary) longer, extending posteriorly to about a vertical line which is as near posterior edge of eye as it is to posterior edge of eye pupil; body banded; the White Crappie.....*Pomoxis annularis* Rafinesque 1818

- 7(4). Scales small, 58 or more in the lateral line; body depth about $\frac{1}{3}$ of the standard length (originally introduced from the Eastern U. S.); two species of Blackbass (Genus *Micropterus*)8
- Scales large, 53 or less in the lateral line; body depth usually about $\frac{1}{2}$ of standard length (originally introduced from the East); two species of Sunfish (Genus *Lepomis*)9
- 8(7). Dorsal fin almost divided into two fins, the shortest spine of the notch less than half as long as the longest spine; upper jaw (maxillary) extending behind hind margin of eye in adults (measured with mouth closed); from 58 to 69 scales in the lateral line; cheek scales in 9 to 12 rows; the Largemouth Blackbass.....*Micropterus salmoides* (Lacépède) 1802
- Dorsal fin less deeply notched, the shortest spine at the emargination being more than $\frac{1}{2}$ the length of the longest spine; upper jaw extending beyond middle of eye pupil but not to hind margin of eye; from 68 to 81 scales in the lateral line; cheek scales in 14 to 18 rows; the Smallmouth Blackbass.....*Micropterus dolomieu* Lacépède 1802
- 9(7). Pectoral fins short and rounded, their length about $\frac{1}{4}$ that of the standard length; mouth large, the upper jaw or maxillary reaching behind front edge of eye (in adults, the upper jaw is two or more times the width of the eye); usually lacking any definite isolated black spot on dorsal fin rays, except for a darkening at ray bases; the Green Sunfish*Lepomis cyanellus* Rafinesque 1819
- Pectoral fins long and pointed, their length about $\frac{1}{3}$ that of the standard length; mouth small, the maxillary not reaching the front edge of eye (in adults, the maxillary is but slightly longer than the width of the eye); possesses a prominent black isolated spot on dorsal fin rays; the Bluegill Sunfish.....*Lepomis macrochirus* Rafinesque 1819
10. Head with scales (Order Cyprinodontodea, Families PECILIIDÆ and CYPRINODONTIDÆ; the former introduced from southeastern U. S., the latter native); seven species and three subspecies of Mosquitofish, Springfish and Pupfish.....11
- Head without scales.....19
- 11(10). Anal fin of male unlike that of female, being modified into a long, narrow reproductive organ; third anal ray unbranched (Family PECILIIDÆ; introduced from the southeast); the Mosquitofish.....*Gambusia affinis* (Baird & Girard) 1853

- Anal fin of male not modified as above for reproduction, but similar in shape to that of the female; third anal ray (counting the rudiments) branched (Family CYPRINODONTIDÆ; native to Nevada); six species and three subspecies of Springfish and Pupfish.....12
- 12(11). Jaw teeth tricuspid; pelvic fins present or absent (Subfamily Cyprinodontinæ; southern Nevada); two species and one subspecies of Pupfish (Genus *Cyprinodon*)....13
- Jaw teeth bicuspid or conical; pelvic fins always absent (Subfamily Fundulinae; southern Nevada); four species and two subspecies of Springfish (Genera *Crenichthys* and *Empetrichthys*).....15
- 13(12). Pelvic fins absent; caudal fin lobate; body dwarfed (confined to Devil's Hole, Ash Meadows, Nye County, Nevada, now a part of the Death Valley National Monument); the Devil Pupfish.....
.....*Cyprinodon diabolis* Wales 1930
- Pelvic fins usually present, occasionally lacking on one side, rarely lacking on both sides; caudal fin rounded or truncate; body generally normal-sized, rarely slightly dwarfed (confined to the Amargosa River system of Nevada and California); one species, the Amargosa Pupfish, with two Nevada subspecies. (*Cyprinodon nevadensis* Eigenmann & Eigenmann 1889).....14
- 14(13). Pectoral fin rays usually 17 (this subspecies has, on the average, more scales between the dorsal and pelvic fins, around the peduncle, and around the body, and more preopercular pores, than the following subspecies) (found only in Ash Meadows, Nye County, Nevada)
.....*Cyprinodon nevadensis pectoralis* Miller 1948
- Pectoral fin rays usually 16 (see top couplet) (found only in Ash Meadows, Nye County, Nevada).....
.....*Cyprinodon nevadensis mionectes* Miller 1948
- 15(12). Jaw teeth bicuspid; jaws equal in length (i.e., the lower jaw not projecting forward beyond the upper jaw); lower pharyngeal teeth conical; intestine markedly coiled (White River region of southeastern Nevada); two species of Springfish (Genus *Crenichthys*).....16
- Jaw teeth conical; jaws unequal in length, the lower jaw projecting forward beyond the upper jaw; lower pharyngeal teeth molarlike; intestine merely S-curved (southern Nye County, Nevada); two species and two subspecies of Springfish (Genus *Empetrichthys*).....17

- 16(15). Lateral dark spots in two series (confined to isolated remnants of the once continuous Pleistocene White River system of eastern and southern Nevada); the White River Springfish.....*Crenichthys baileyi* (Gilbert) 1893
- Lateral dark spots in a single series (known only from the Railroad Valley system directly west of White River); the Railroad Valley Springfish.....*Crenichthys nevadæ* Hubbs 1932
- 17(15). Lateral scales usually 30 or less in number; downward slope of snout quite marked so that mouth lies below the plane of longitudinal section; (occurs only in Ash Meadows, Nye County, Nevada); the Ash Meadows Springfish.....*Empetrichthys merriami* Gilbert 1893
- Lateral scales usually 31 or more; downward slope of snout distinctly less abrupt so that the mouth lies approximately on the plane of longitudinal section (known only from Pahrump Valley, Nye County, Nevada); one species, the Pahrump Springfish, divided into three subspecies.....(*Empetrichthys latos* Miller 1948)....18
- 18(17). Confined to Manse Ranch Spring, Pahrump Valley, Nye County, Nevada*Empetrichthys latos latos* Miller 1948
- Confined to Pahrump Ranch Spring, Pahrump Valley, Nye County, Nevada.....*Empetrichthys latos pahrump* Miller 1948
- Confined to Raycraft Ranch Spring, Pahrump Valley, Nye County, Nevada.....*Empetrichthys latos concavus* Miller 1948
- 19(10). Body scaleless; dorsal and pectoral fins each with a strong spine (Order Ostariophysodea, Family AMEIURIDÆ; all originally introduced from the Eastern U. S.); 4 species of Catfish.....20
- Body with scales; none with pectoral fin spines, and only two species with dorsal fin spines (Trout, Carp and Suckers)23
- 20(19). Tail fin forked; two species of catfish (Genus *Ictalurus*) 21
- Tail fin square or convex; two species of bullheads (Genus *Ameiurus*)22
- 21(20). Anal fin rays from 25 to 32 in number; the Channel Catfish.....*Ictalurus punctatus* (Rafinesque) 1818
- Anal fin rays from 19 to 22 in number; the White Catfish.....*Ictalurus catus* (Linnæus) 1758
- 22(20). Anal fin rays from 21 to 22 in number; pectoral fin spine with strong barbs on posterior edge (appreciable in all specimens except old adults by the following test — grasp

- the spine in the plane of the fin between thumb and forefinger, hold tightly, and pull outward; if the grasp holds, it is this species); inter-radial membranes of anal fin not black; the Brown Bullhead.....
Ameiurus nebulosus (LeSueur) 1819
- Anal fin rays from 17 to 20 in number; pectoral spine without strong, definite barbs on posterior edge; inter-radial membranes of anal fin jet black; the Black Bullhead.....*Ameiurus melas* (Rafinesque) 1820
- 23(19). Two dorsal fins present, the second one a small, fleshy appendage near the tail; branchiostegal rays 6 or more (Order Isospondyloidea, Family SALMONIDÆ; both native and introduced species of Trout, Salmon and Whitefish); nine species.....24
- Only a single dorsal fin present; branchiostegal rays 3 (Order Ostariophysodea, Families CYPRINIDÆ and CATOSTOMIDÆ, Carp and Suckers, respectively; mostly native species); 25 species and 4 subspecies.....32
- 24(23). Mouth small, the maxillary process not extending behind the eye in adults, usually ending before or just at anterior edge of eye; jaw teeth weak; scales in fewer than 105 oblique lines on sides (Subfamily Coregoninæ of the family SALMONIDÆ; native to the Lahontan system of Nevada; and the Columbia system to the north); the Mountain Whitefish.....
Coregonus williamsoni Girard 1856
- Mouth large, the maxillary process extending at least to hind edge of eye in adults, usually considerably posterior to the eye; jaws usually bearing strong teeth; mouth deeply cleft; side scales in more than 115 oblique rows (Subfamily Salmoninæ of the family SALMONIDÆ; native and introduced species); 8 species of Trout and Salmon25
- 25(24). Anal fin elongate, from 13 to 19 rayed (rarely with 12 to 19 rays); vomer narrow, long, flat, with weak teeth; gillrakers 19-40 on first gill arch; branchiostegals 13-19; species with or without black spots, the adults with anal and dorsal fins seldom spotted; two species of salmon (Genus *Oncorhynchus*).....26
- Anal fin short, 9-12 rayed (rarely 13); gillrakers 20 or less on first gill arch; branchiostegals 10-20; dorsal fin black-spotted; 6 species of Trout and Charr, both native and introduced (Genera *Salmo* and *Salvelinus*).....27
- 26(25). Gillrakers comparatively short and few in number, 19-28 on the first gill arch (rarely 29) (originally ascended the

- tributaries of the Snake River in northeastern Nevada — Owyhee, Salmon, Bruneau and Jarbridge rivers; planted unsuccessfully in west-central Nevada); the King Salmon *Oncorhynchus tshawytscha* (Walbaum) 1792
- Gillrakers comparatively long and numerous, 30-50 in number on the first gill arch (11 to 24 plus 20 to 26) (a subspecies of the Red or Sockeye salmon, *Oncorhynchus nerka* (Walbaum) 1792, introduced into Nevada from the Pacific Northwest); the Kokanee Red Salmon..... *Oncorhynchus nerka kennerlyi* (Suckley) 1861
- 27(25). Species with light spots, white or gray, on a darker background; often with red spots on sides; with over 190 scale rows crossing the lateral line; vomer boat-shaped, the shaft depressed and without teeth (introduced and native species); three species of Charr (Genus *Salvelinus*) 28
- Species with dark spots on a lighter background; fewer than 190 scale rows crossing the lateral line; vomer flat, its toothed surface plane, teeth on vomerian shaft in alternating rows or in one staggered row, those on the shaft placed directly on surface of bone, not on a free crest (introduced and native species); three species of Trout (Genus *Salmo*)..... 30
- 28(27). Vomer with a raised crest extending backward from the head of the bone, this crest armed with strong teeth; species gray-spotted, without red spots; fins not markedly bright-edged; the tail prominently forked in adults (introduced from the Great Lakes); the Lake Trout..... *Salvelinus namaycush* (Walbaum) 1792
- Vomer without a raised crest which extends backward, the head of the bone toothed; species red-spotted in life, the lower fins with bright silver edgings; tail weakly forked in adults..... 29
- 29(28). Back unspotted, but strongly mottled with olive and black (i.e., the spots run together creating a mottled effect); dorsal and caudal fins finely mottled; body stouter, the head heavy (introduced from the Eastern U. S.); the Eastern Brook Trout..... *Salvelinus fontinalis* (Mitchill) 1815
- Back not mottled, but with light spots like those on the sides of the body, only smaller and paler; dorsal and caudal fins unmarked and clear; body slimmer (native to the West Coast, ranging into the Nevada tributaries of the Snake River); the Dolly Varden Trout..... *Salvelinus malma* (Walbaum) 1792

- 30(27). Red dash of color on the dentary (between lower jaw and isthmus) evident in life; no red spotting on flanks; vertebrae from 58 to 62 in number (usually 60-61); dorsal rays 9-11 (usually 10); anal fin rays 9-11; maxillary process in adults extending behind the eye, measuring about 1.6 to 2.25 into the head; hyoid teeth (those behind the patch of teeth on tip of tongue) usually present, but few and scattered (our one native trout, originally occurring throughout the entire Lahontan drainage system, and phenomenally abundant in the Pyramid-Truckee-Tahoe system; a subspecies of the Cutthroat or Blackspotted Trout, *Salmo clarki* Richardson 1836); (the Lahontan Cutthroat Trout).....
*Salmo clarki henshawi* Gill & Jordan 1878
- No red dash of color on the dentary present in life; dorsal fin rays 10-13 (usually 11-12); maxillary process on adults shorter; hyoid teeth always absent (two introduced species)31
- 31(30). Vertebrae from 56 to 59 in number (usually 57-58); body color brownish-yellow usually with a few red spots on sides; spotting scarcely developed on tail (caudal) fin; adipose fin of young individuals orange, without dark margining or spotting (originally introduced from Europe; two subspecies of the Brown Trout, *Salmo trutta fario* and *S. t. levenensis* have been introduced and mixed so completely in hatchery practice that they are no longer distinguishable as separate entities in this country); the Brown Trout.....*Salmo trutta* Linnæus 1758
- Vertebrae 59-65 (usually 63); color gray-to-blue above, the reddish lateral band usually but slightly interrupted by faint parr marks on adults; no red spotting on flanks; spotting well-developed on tail fin; adipose fin of young specimens olive, with black margining or spotting (introduced into Nevada from the Pacific Coast; many of the numerous subspecies of the Rainbow Trout, *Salmo gairdneri* Richardson 1836, have been mixed with each other, and the Cutthroat, by hatchery practice); (the Southcoast Rainbow Trout).....
*Salmo gairdneri irideus* Gibbons 1855
- 32(23). Origin (front end) of anal fin from $1\frac{1}{2}$ to $2\frac{1}{2}$ times as far from tip of snout as from base of tail fin; tail fin rays 18 in number (16-branched), pharyngeal teeth numerous, in a single row, arranged like the teeth of a comb; mouth usually directed downward, excessively protractile and suckerlike, with or without papillose lips (Family

- CATOSTOMIDÆ; all species native to the area); nine species of Suckers.....33
- Origin of anal fin from 1 to 1½ times as far from tip of snout as from base of tail fin; tail fin rays usually 19 (17-branched); pharyngeal teeth few, in from 1 to 3 rows, not comb-like; mouth not especially directed downward, lacking papillose lips (Family CYPRINIDÆ; all but two species native to the area); 16 species and 7 subspecies of Carp, Chub, Dace, Shiners, Minnows, etc.41
- 33(32). Nuchal (neck) region with a high, sharp-edged hump, formed by the greatly enlarged and expanded interneural vertebral spines; the hump is largest in adult specimens (native to the Colorado River); the Humpback Sucker....
.....*Xyrauchen texanus* (Abbott) 1860
- Nuchal region without such a sharp-edged hump, at most merely with an upslope on the otherwise smoothly curving dorsal outline; various species of Suckers.....34
- 34(33.) Mouth semi-terminal, the lower jaw oblique, the lips thin, lacking papillæ (known only from Pyramid Lake, western Nevada, with related species in Klamath Lakes, Oregon and Utah Lake, Utah); the Cui-ui Sucker (Indian pronunciation *Koo-ee-you-ee*)
.....*Chasmistes cujus* Cope 1883
- Mouth inferior (i.e., opening directly downward), lips thick with many papillae; common Suckers.....35
- 35(34). With a distinct notch at the corner of the mouth; edge of jaw inside the lower lip with a hard cartilaginous sheath; upper lip recurved; a small flap or "scale" of skin present at the base of each pelvic fin (in axil) (native to the area); two species of Mountainsucker (Genus *Pantosteus*)36
- Without a distinct notch at corner of mouth between upper and lower lips, although occasionally a very slight indentation occurs in some individuals; upper lip not recurved but nearly flat; edge of jaw inside lower lip without a hard cartilaginous sheath, the sheath, if present, being rather flexible; small flap or "scale" of skin absent from pelvic fin axil (native to the area); five species of common Suckers occurring in various parts of the Great Basin (Genus *Catostomus*)37
- 36(35). Fontanelle (space between parietal and frontal head bones) open; more than 35 scales in front of the dorsal

- fin (common throughout the Lahontan drainage system of western Nevada); the Lahontan Mountainsucker.....
Pantosteus lahontan Rutter 1903
- Fontanelle closed; less than 35 scales in front of dorsal fin; (restricted to the relict White River system of eastern Nevada); the White River Mountainsucker.....
Pantosteus intermedius (Tanner) 1942
- 37(35). Body scales very small to moderately large, about 80 to 115 along the lateral line; three species of common Suckers38
 Body scales very large, about 60-80 along the lateral line; two species of common Suckers.....40
- 38(37). Lower lips not deeply incised, allowing several transverse rows of papillae to cross the midline between the incision and the forward edge of the lower jaw (lateral scales 92-114, dorsal fin rays 11-14; found in the Columbia River and its tributaries, including those in Nevada); the Columbia Fine-scaled Sucker....*Catostomus columbianus*(Eigenmann & Eigenmann) 1893
 Lower lips deeply incised, usually allowing room for only one row of papillae to cross the midline.....39
- 39(38). Dorsal fin rays from 10 to 12 in number; caudal peduncle thick and broad, its least depth about 12 times into body length; lips moderate-sized for the genus (the commonest sucker of the Lahontan system of western Nevada); the Tahoe Sucker.....
*Catostomus tahoensis* Gill & Jordan 1878
- Dorsal fin rays 13-15; caudal peduncle very slim and narrow, its least depth about 16 times into body length; lips conspicuously enlarged (occurs in the Colorado River); the Flannelmouth Sucker.....
*Catostomus latipinnis* Baird & Girard 1853
- 40(37). Dorsal fin rays from 12 to 15 in number, usually more than 12; lobes of lower lip long and full, extending back to below the nostrils, their length (from tip of upper lip) more than one-half the depth of the caudal peduncle (Columbia-Snake rivers system); the Columbia Coarse-scaled Sucker.....*Catostomus macrocheilus* Girard 1856
- Dorsal fin rays 11-13; lobes of lower lip short, not extending back to below nostrils, their length (from tip of upper lip) about one-half, or less, the depth of the caudal peduncle (occurs in tributaries of the Bonneville drainage system in extreme eastern Nevada); the Utah Sucker
*Catostomus ardens* Jordan & Gilbert 1881
- 41(32). A spine, usually serrated, developed at front of the dorsal and anal fins; dorsal fin very long, with more than 12

- soft rays, the anterior rays much longer than posterior rays; inner border of pelvic fins not adhering to the body (two introduced Old World species).....42
- A smooth double spine developed at front of dorsal fin, the posterior half of the double spine smaller and fitting into a longitudinal groove in the back of the larger anterior half; dorsal fin shorter, with less than 10 soft rays, the anterior rays less distinctly set off from posterior rays by length; inner border of pelvic fins adhering to the body (two peculiar minnows of the Southwest).....43
- No spines of any kind developed in dorsal or anal fins (certain species occasionally have the first simple ray of dorsal or anal fins or both hardened in very old individuals, but it is not a sharp spine); dorsal fin shorter, with less than 12 soft rays; inner border of pelvic fins not adhering to the body (majority of the, chub, dace shiners, minnows, etc., comprising the family Cyprinidæ in Nevada, all native); 12 species and 7 subspecies....44
- 42(41). Barbels in two pairs on upper jaw; more than 32 scales in the lateral line (except in the "mirror" or "leather" varieties) (originally introduced into Europe from Asia, and from Europe into America, and now widespread in Nevada in suitable slow and standing water); the Asiatic Carp.....*Cyprinus carpio* Linnaeus 1758
- Barbels lacking; less than 30 scales in the lateral line (introduced into both Europe and the Americas from Asia as an ornamental species, and occasionally becomes established in the wild, when it reverts to its original olive coloration); the common Goldfish.....*Carassius auratus* (Linnaeus) 1758
- 43(41). Maxillary barbels present; body scaleless (an occasional individual has a few scales on the back and elsewhere) (known from the Virgin River of extreme southern Nevada, and elsewhere in the Colorado River system); the Woundfin.....*Plagopterus argentissimus* Cope 1874
- Maxillary barbels absent; body covered with small scales (occupies portions of the disrupted Pleistocene White River system of eastern and southeastern Nevada); the White River Spinedace.....*Lepidomeda vittata* Cope 1874
- 44(41). Species with only a single row of pharyngeal teeth, the lesser or outer row never developed.....45
- Species with two rows of pharyngeal teeth, the lesser or outer row occasionally lacking on one side.....48
- 45(44). Scales in the lateral line numbering 100 or more; pharyngeal teeth 6/6 or 6/5; intestine about 7 times the body

- length (one collection in the vicinity of Reno, Nevada, has contained an individual of the Sacramento Blackfish and hybrids presumably between this species and the Lahontan Tui Chub [*Siphateles bicolor obesus*], the former apparently introduced with sunfish from the Sacramento Valley during fish rescue work; original distribution, the Sacramento River system); the Sacramento Blackfish *Orthodon microlepidotus* (Ayres) 1854
- Scales in the lateral line 90 or less; pharyngeal teeth 5/5 or 5/4; intestine not more than 3 times the body length 46
- 16(45). Horny sheaths covering the lips of both jaws (confined to the type locality of Soldier Meadows, Humboldt County, Nevada, in warm waters); the Soldier Meadows Dace *Eremichthys acros* Hubbs & Miller 1948
- A horny sheath covering only the lip of the lower jaw (this horny sheath is an external covering not to be confused with the small cartilaginous plate on the upper jaw of this species, a plate which is not visible externally, but is covered by the fleshy upper lip) (a member of the Columbia River system fauna); the Chiselmouth *Acrocheilus alutaceum* Agassiz & Pickering 1855
- Horny sheaths lacking on both jaws 47
- 17(46). Scales in the lateral line larger, less than 65; maxillary smaller, not reaching anterior edge of eye; intestine longer, about equal in length to the standard body length; pharyngeal arch uniformly and smoothly rounded in the vicinity of the "heel" (one of the commonest forms in the Lahontan drainage system, a subspecies of the more widespread Tui Chub, *Siphateles bicolor* (Girard) 1856; (the Lahontan Tui Chub) *Siphateles bicolor obesus* (Girard) 1856
- Scales in the lateral line smaller, more than 65; maxillary larger, reaching posteriorly to about the anterior edge of the eye; intestine shorter, only about one-half the standard length; pharyngeal arch with a quite prominently developed "heel" which breaks the otherwise smooth contour of the pharyngeal bone (confined to the type locality of Warm Springs, Clark County, Nevada, in warm water); the Moapa Dace *Moapa coriacea* Hubbs & Miller 1948
- 18 44. A barbel usually present on the posterior angle of the maxillary process, small but seldom obsolescent except in very young individuals (up to 50% of specimens in any given population may lack barbels, hence the necessity of extensive collections in determining these forms)

- (occurs over the entire state); 4 subspecies of the Speckled Dace, *Rhinichthys nubilus* (Girard) 1856 in Nevada 49
- Barbels always lacking (remainder of the family Cyprinidæ) 50
- 49(48). Rivers Salmon, Jarbridge, Bruneau and Owyhee, the Snake River tributaries of northeastern Nevada; (the Snake River Speckled Dace).....
.....*Rhinichthys nubilus carringtoni* (Cope) 1871
- Rivers Humboldt, Truckee, Carson, Walker and associated lakes (— Lahontan system) of western Nevada; (the Lahontan Speckled Dace).....
.....*Rhinichthys nubilus robustus* (Rutter) 1903
- Amargosa River system of southwestern Nevada — southeastern California; (the Amargosa Speckled Dace).....
.....*Rhinichthys nubilus nevadensis* Gilbert 1893
- White River system of eastern and southeastern Nevada; (the White River Speckled Dace).....
.....*Rhinichthys nubilus velifer* Gilbert 1893
- 50(48). Pharyngeal teeth subconical, scarcely hooked, sharp-edged, the lower limb of the pharyngeal bone greatly elongated; body long and pike-like (Genus *Ptychocheilus*) 51
- Pharyngeal teeth compressed, close-set, strongly hooked; pharyngeal bone of the usual form; body not elongated and pike-like 52
- 51(50). Scales in the lateral line numbering from 73 to 86 (occurs in the Columbia River system); the Columbia Squawfish
.....*Ptychocheilus oregonense* (Richardson) 1836
- Scales in the lateral line numbering about 90 (a member of the Colorado River system); the Colorado Squawfish
.....*Ptychocheilus lucius* Girard 1856
- 52(50). An accessory “scale” or flap of skin present in the axil (base) of the pelvic fin; caudal peduncle short and relatively stout, from 10-11 times into body length; sides with a deep orange-to-red broad band in adults of both sexes (native to the area); two species of Redshiners (Genus *Richardsonius*) 53
- No accessory “scale” or flap of skin present in pelvic fin axil; caudal peduncle varying from about the proportions of *Richardsonius* to a slender, pencil-like structure; adults without the above coloration (native to the area); two species of Gila (Genus *Gila*)..... 55
- 53(52). Rays of anal fin numbering from 8 to 9, rarely 10; body comparatively slender (Lahontan drainage system); the

- Lahontan Redshiner
Richardsonius egregius (Girard) 1859
- Rays of anal fin 10-22; body comparatively robust (Snake River tributaries of northeastern Nevada); one species, the Northern Redshiner, with several Nevada forms.....
(Richardsonius balteatus (Richardson) 1836)....54
- 54.53. Anal fin rays 10-13, usually 11-12 (Bonneville basin and the upper Snake River drainage).....
Richardsonius balteatus hydrophlox (Cope) 1872
- (Anal fin rays 13-22, usually 14-18 (Columbia-Snake system below the falls of the Snake River); intergrades with the above subspecies in extreme northeastern Nevada, as below:.....
Richardsonius balteatus balteatus (Richardson) 1836
- Anal fin rays usually 13-44 (northeastern Nevada, in tributaries of the Snake River); intergrading form between the above two subspecies.....
Richardsonius balteatus :: balteatus X hydrophlox
- 55(52). Origin (front end) of dorsal fin immediately over the origin of the pelvic fins; lateral line scales numbering 70 or less; caudal peduncle relatively deep, resembling that of a *Siphateles* (found in the Bonneville Basin of eastern Nevada as well as the tributaries to the upper Snake River); the Utah Gila.....*Gila atraria* (Girard) 1856
- Origin of dorsal fin behind the origins of the pelvic fins; lateral line scales approximately 80 or more; caudal peduncle moderately robust to extremely slender and pencil-shaped (southern Nevada); one species, the Colorado Gila, with four Nevada subspecies.....
(*Gila robusta* Baird & Girard 1853)....56
- 56(55). Dorsal fin rays 8-10, usually 9; anal fin rays 7-10, usually 9; pelvic fin rays usually 9/9, rarely 10/10; body fully scaled, scales numbering from 79 to 96 in the lateral line; basal radii of scales poorly developed; nuchal hump detectable in older fish, caudal peduncle least depth goes into head length from 3.3 to 4.3 times; mainly a small river form (Colorado River).....
*Gila robusta robusta* Baird & Girard 1853
- - Dorsal fin rays 9-10; anal fin rays 9-10; pelvic fin rays from 9 9 to 10/10; body scales occasionally lacking over portions of dorsum or venter; scales 77-89 in the lateral line; basal radii of scales faintly present in 2 out of 5 scales; nuchal hump absent; caudal peduncle least depth from 4.1 to 5.2 times into head length; a large, swift water form (Virgin River), regarded by Miller (1946)

- as probably an intergrade between *robusta* and *elegans*
 -----*Gila robusta seminuda* Cope & Yarrow 1875
- Dorsal fin rays 10-11; anal fin rays 10-11; pelvic fin rays usually 9/9, rarely 10/10; body scales often lacking over dorsum, venter, and caudal peduncle, or consisting there of minute embedded scales; lateral line scales 75-88; basal radii completely lacking in scales; nuchal hump prominent; caudal peduncle least depth from 5.0 to 6.5 into head length; a swift water type (Colorado River).....
 -----*Gila robusta elegans* Baird & Girard 1853
- Dorsal fin rays 9; anal fin rays 9; pelvic fin rays 9/9; body fully scaled, scales numbering from 89-94 in the lateral line; basal radii of scales conspicuous; nuchal hump absent; caudal peduncle least depth from 3.3 to 4.1 into head length; an inhabitant of small streams, springs and pools (White River system of southeastern Nevada);....
 -----*Gila robusta jordani* Tanner 1950

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Discussion of the Colonial Tube-Building Polychaetous Annelid

Dodecaceria fistulicola Ehlers¹

By DONALD J. REISH

The cirratulid genus *Dodecaceria* Oersted, 1843, has been mentioned but once in paleontological literature (Packard, 1942, p. 778). In his paper, Packard suggested that the recent *Dodecaceria fistulicola* Ehlers, 1901, the "Micocene" [L-M Pliocene, *vide*, Weaver, et al, 1944, pl. 1] ?*Serpula octoforis* Dall, 1909, and the Pleistocene "*Serpula*" *saxistractoris* Howell and Mason, 1937, are identical. The Pliocene and Pleistocene species were originally questionably referred to *Serpula* Linnaeus, 1767.

The loan of a fossil colonial polychaete by Dr. William H. Easton has provided an opportunity for comparing fossil and recent specimens of this species. Further consideration of them is desirable in order to review the literature on both forms which are here presumed to be identical.

The recent *D. fistulicola* has been reported by different authors from various parts of the Pacific Ocean and from South Africa (see synonymy). On the Pacific Coast of the United States this species, under favorable conditions, forms an important element of the intertidal polychaete fauna. It may construct extensive calcareous matrices under optimum conditions and could have left extensive fossil remains of its calcareous secretions.

The author wishes to express his thanks to Prof. J. H. Day, University of Cape Town, South Africa, for his gift to the Allan Hancock Foundation of specimens of *Dodecaceria fistulicola*, to Dr. B. F. Howell, Princeton University, for lending the holotype of "*Serpula*" *saxistractoris*, to Dr. William H. Easton, University of Southern California, for the loan of a fossil specimen from the Santa Margarita formation of California, and to the administration of the Allan Hancock Foundation for aid which has made this study possible. The synonymy of the recent species is taken largely from Hartman (in litt.).

¹Contribution no. 101 from the Allan Hancock Foundation, University of Southern California.

Family CIRRHATULIDAE Carus
Genus *Dodecaceria* Oersted, 1843

Generic diagnosis. The body is vermiform. The prostomium is obtuse to triangular and generally without eyes. The peristomium is without setae, triangular, and with two large palpi. Each of the anterior 4 to 8 segments has a pair of tentacular cirri. The setae are entirely simple. Both the notopodium and neuropodium include a long pointed one and a thicker, acicular-type setae. The latter in the posterior segments is provided with a concavity at its distal portion.

Dodecaceria fistulicola Ehlers, 1901

Plate 20 figs. 1-4

not *Sabella pacifica* Grube, 1859. Sabellidae.

Sabella pacifica Fewkes, 1889, Bull. Essex Inst., vol. 21, p. 132, pl. 7, figs. 1-2. Santa Barbara, Calif.

Dodecaceria fistulicola Ehlers, 1901, Zool. Jahrb. Suppl., vol. 5, p. 266, Chile.

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?*Serpula octoforis* [sic] Dall, 1909, U. S. Geol. Survey, Prof. paper 59, pp. 138-9, pl. 20, figs. 1-2. Miocene of Coos Bay, Oregon.

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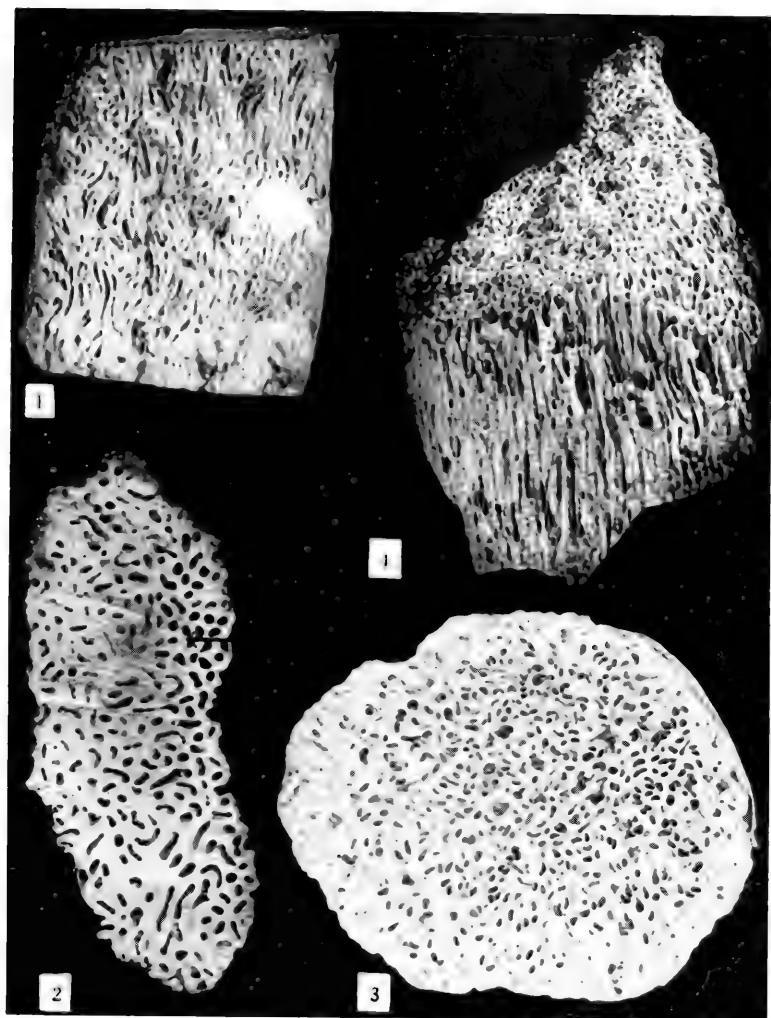


Plate 20

Dodecaceria fistulicola Ehlers

Fig. 1. Colony from Miocene of Santa Margarita formation, Calif., showing nature of tubes, X 0.6.

Fig. 2. Colony from Miocene of Santa Margarita formation, Calif., cross-section, arrow indicates rim of tube containing secondary deposition, X 1.1.

Fig. 3. Holotype of "*Serpula*" *saxistractoris* Howell and Mason, X 0.55.

Fig. 4. Recent colony that was growing under optimum conditions in San Mateo County, Calif., X 0.53.

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Material examined. — Fossil: "*Serpula*" *saxistructoris* Howell and Mason, holotype (Princeton University Paleontological Collections no. 42821), from Pleistocene at Dead Man's Island, San Pedro, Calif., and *Dodecaceria fistulicola* Ehlers (University of Southern California Paleontological Collections no. 785, also in the Allan Hancock Foundation annelid collections) from Upper Miocene in the Santa Margarita formation on the east spur where the power line crosses Gypsum Canyon, Branch Mountain Quadrangle, San Luis Obispo County, Calif. The latter was collected by a field geology class of the University of Southern California in July 1948.

The Santa Margarita specimen was originally approximately rectangular, measuring 115 mm in length, 70 mm wide, and 45 mm thick. The surface is perforated by numerous holes and by portions of broken tubes (Pl. 20, fig. 1) of variable length in which the worm formerly lived. The specimen was sectioned (Pl. 20, fig. 2) to study the tubes. Twenty measurements of tube diameter range from 1.05 to 2.0 mm with a mean of 1.4 mm. Secondary deposition occurred in many of the tubes which partially or completely filled the opening (Pl. 20, fig. 2, arrow). Measurements of the original diameters of 20 tubes range from 1.4 to 2.4 mm with a mean of 1.85 mm. Five counts show an average of 28 tube openings per square centimeter.

Dall (1909) described ?*Serpula octoforis* from the "Miocene" [Pliocene] of Fossil Point, Coos Bay, Oregon, but did not furnish measurements of the tubes. Packard (1942), at Dr. Olga Hartman's suggestion, considered Dall's species to be identical with the recent *Dodecaceria fistulicola* Ehlers, and suggested that "*Serpula*" *saxistructoris* Howell and Mason also apparently is identical.

Measurements by the author of the holotype of "*S.*" *saxistructoris*, show that 20 tube openings range in diameter from 1.5 to 2.4 mm with a mean of 1.9 mm (pl. 20, fig. 3). The average of five counts is 25 tube openings per square centimeter.

Recent: Littoral regions including San Mateo County, Half Moon Bay, Portuguese Bend (collected by Dr. Olga Hartman) all in California, Cape Arago, Oregon (collected by Mr. Fred Ziesenhenné), and from South Africa (collected by Prof. J. H. Day). All specimens are deposited in the Allan Hancock Foundation annelid collection.

Measurements were made of specimens from California, Oregon, and South Africa. For each specimen the diameters of 20 openings were determined and the number of tubes in five unit areas counted. The results are as follows: Portuguese Bend, range 1.0 to 1.7 mm, mean 1.4 mm, 25 openings per cm²; San Mateo Co., range 1.25 to 2.0 mm, mean 1.6, 26 openings per cm²; Half Moon Bay, range 1.65 to 2.4 mm, mean 2.0 mm, 25 openings per cm²; Cape Arago, range 0.6 to 1.05 mm, mean 0.9 mm, 27 openings per cm²; and South Africa, range 0.75 to 1.5 mm, mean 1.1 mm, specimen too small to determine the number of openings per square centimeter.

Remarks. — Size and spacing of the tubes are the only characters available for comparison. Length of tubes does not seem to be significant because colonies contain individuals in various stages of development. Measurements and counts of the fossil specimens fall within the ranges of the recent ones and there seems to be no justifiable reason for concluding that more than one species is represented. Plate 20, fig. 4 shows a recent colony that grew under favorable conditions.

Distribution. — Fossil: Miocene of the Santa Margarita formation, San Luis Obispo County, Calif., Pliocene of Fossil Point, Coos Bay, Oregon, and Pleistocene of Dead Man's Island, San Pedro, Calif. Recent: Reported from British Columbia to Southern California, Gulf of California, Chile, New Caledonia, Palau Islands, Ryukyu Islands, French Indo China, Northern Australia, and South Africa.

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A WATER COOLER FOR TRANSPORTING HEAT SENSITIVE ANIMALS, ESPECIALLY INSECTS

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Los Angeles 29, California

Since 1930, the writers have been collecting cone-nosed bugs (*Triatoma* and *Paratriatoma*) in search for natural infections of *Trypanosoma cruzi* Chagas in Southwestern United States. Several hundred specimens have succumbed to heat shock or exposure after being removed from cool burrows of rodents (*Neotoma*) or protected retreats in human abodes and placed in collecting cartons (Wood, 1941a).

During summer trips into Arizona, New Mexico, and Texas (Wood and Wood, 1938; Wood, 1941b), many bugs were saved by draping wet towels over hardware cloth baskets containing collecting cartons of insects. Some of these were successfully brought through the Colorado desert at night in this way. Usually, these preparations did not protect first instar nymphs and sometimes many adults and larger nymphs died from heat exposure. Therefore, it became necessary to devise some more efficient means of protecting the insects from lethal exposure to heat and dryness.

During the summer of 1949, the senior author designed the water cooler illustrated in Plate 21 for protecting live animals, especially *Triatoma*, from heat shock and exposure. The cooler was assembled by Denny G. Constantine.

The film can base of the cooler is 30.5 cm. in diameter and 8.5 cm. deep. The inverted aluminum cake pan measures 23 cm. by 4 cm. The hardware cloth cylinder encircling the cake pan is 23.5 cm. across and 21 cm. high. The cooler lid measures 29 cm. by 6 cm. The bottom of the film can is covered with a layer of absorbent cotton 1 cm. thick plus circles of absorbent cotton inside the inverted cake pan. A continuous band of absorbent cotton 3 cm. thick encircles the burlap covered hardware cloth cylinder inside the film can. Two layers of burlap, with a separating, sewed in layer of absorbent cotton, cover the hardware cloth circular frame for the lid. This lid covers the larger burlap covered hardware cloth cylinder which fits tightly over the inverted cake pan. Complete saturation of the cotton and burlap produces effective cooling for three hours or more at high temperatures.

¹The writers are indebted to the California Forest and Range Experiment Station and Division of Zoology at Davis, University of California, for use of facilities at the San Joaquin Experimental Range, O'Neals, California.

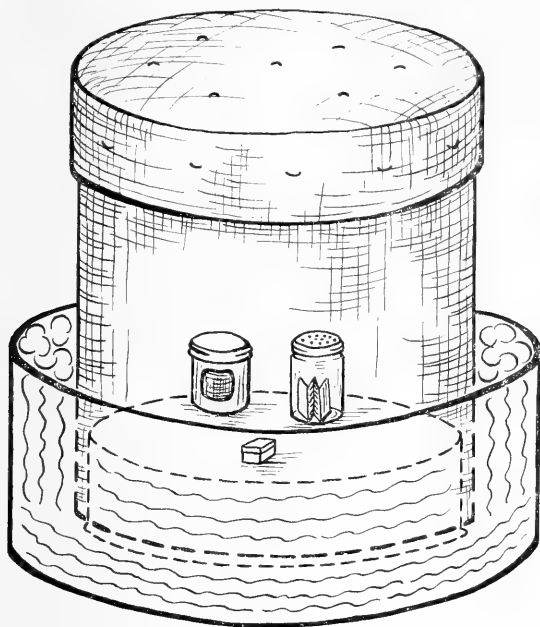


Plate 21

This is accomplished by pouring water on to the cake pan until covered and allowing it to stand for five minutes. The sides and top are soaked under a stream of water. The lid and large cylinder dry out first but if these are sprinkled every two hours, maximum effectiveness of the cooler is maintained.

One thousand four hundred and seventy-one experimental insects have been successfully transported during high temperatures without loss of a single specimen in the cooler illustrated. Sixteen *Triatoma rubida uhleri* nymphs (1 fifth, 3 third, 9 second and 3 first instars) were collected July 16, 1949, twelve miles southwest of Congress Junction, Yavapai County, Arizona, with the aid of Denny Constantine and John McManus. The bugs were carried through the Colorado desert to the Mountaineer Mine north of Blythe in Riverside County on July 16th and then to Los Angeles on the afternoon of July 17th. The Fahrenheit maximum and minimum temperatures² for both days at Blythe were 112° and 81°. Maximum temperature for July 17th at stations near the route traveled were: Indio 107°, Palm Springs 112° and Beaumont 100°.

² All Fahrenheit temperatures are from U. S. Weather Bureau data.

On July 1, 1950, 241 bugs were carried in the cooler on the floor of the rear seat of a sedan from Los Angeles to the San Joaquin Experimental Range at O'Neals, California. The approximate midpoint of this route is Bakersfield with afternoon protection necessary either way if high temperatures prevail. The maximum temperatures at Bakersfield and Fresno were 115° and 109°, respectively. There were 140 *Triatoma protracta* (24 adults and 15 fifth, 10 fourth, 3 third, 5 second and 83 first instar nymphs), 52 *Triatoma rubida uhleri* (12 adults and 40 nymphs of various instars), 10 *Triatoma longipes* (1 adult and 9 first instar nymphs), and 39 *Paratriatoma hirsuta* (7 adults and 5 fifth, 16 fourth, 4 third and 7 second instar nymphs).

On June 19, 1951, 414 bugs were taken from Los Angeles to O'Neals with maximum temperatures at Bakersfield and Fresno of 93° and 88°, respectively. There were 326 *Triatoma protracta* (43 adults and 10 fifth, 9 fourth, 4 third and 260 first instar nymphs), 47 *Triatoma rubida uhleri* (3 adults and 44 nymphs of various instars), 2 *Triatoma longipes* (1 third and 1 second instar nymphs), 12 *Paratriatoma hirsuta* (10 adults and 2 fifth instar nymphs), and 27 *Cimex pilosellus* of various instars in the cooler.

On September 8, 1951, 800 bugs were transported in the cooler from O'Neals to Los Angeles with maximum temperatures along the route as follows: Bakersfield 95°, Sandbergs 93°, and San Fernando 102°. In this group were 495 *Triatoma protracta* (15 adults and 8 fifth, 97 fourth, third and second, and 375 first instar nymphs), 109 *Triatoma rubida uhleri* (4 adults and 31 fifth, 4 fourth and 70 third, second and first instar nymphs), 2 *Triatoma longipes* (1 fourth and 1 third instar nymphs), 1 first instar nymph of *Paratriatoma hirsuta* and 193 *Cimex pilosellus* (mostly nymphs of various instars).

Three types of bug containers were used in these experiments, heavy cardboard mailing tube collecting cartons with screen windows, glass jars (60 mm. x 90 mm. or smaller) with perforated metal lids ordinarily used in laboratory culture, and plastic boxes. The plastic boxes³ were of three sizes, 50 x 50 x 20 mm., 50 x 25 x 20 mm., and 25 x 25 x 20 mm. The use of plastic boxes increases the carrying capacity of the cooler for experimental insects where isolation is essential. Care is necessary to avoid sunlight on the plastic boxes which otherwise allow ample air circulation for these bugs.

The 49 insects were confined to the screened cardboard cartons while the 50 specimens were in glass jars and screened collecting cartons. For the June '51 specimens, 353 were in glass jars and 61 were in plastic boxes. Five hundred nineteen of the

³ Obtainable from R. P. Cargille, New York 6, New York.

September '51 specimens were in glass jars and 281 were in plastic boxes.

Additional animals successfully transported on July 17, 1949, from the Mountainer Mine were 2 Arizona house bats, *Myotis v. velifer*, 2 Mexican free-tailed bats, *Tadarida mexicana*, 1 desert Yuma bat, *Myotis y. yumanensis* and 18 desert brown bats, *Eptesicus fuscus pallidus*. These bats were inside cloth bags in the cooler which rested on the floor of the rear seat of a sedan with forward vents and all windows open thus exposing it to a floor draft of hot air.

On September 8, 1951, while traveling from O'Neals to Los Angeles, this cooler plus a cardboard box containing 6 *Mus musculus* (white mice), 1 *Peromyscus truei gilberti* with 2 nursing young, and 1 female *Triatoma protracta* in a collecting carton were carried in the inside rear corner of an open luggage trailer with tarpaulin cover to protect the animals from the sun. The cardboard box was perforated for aeration and the rodents were confined to 130 mm. square hardware cloth cages on a layer of sawdust. The water saturated cooler contained 800 live bugs. The position of the containers in the trailer was such that a constant flow of air circulated about the cardboard box and cooler. The cooler was dampened once during the trip at Bakersfield. The bugs in the cooler survived the trip. The 6 white mice were alive on arrival in Los Angeles but the female *Peromyscus* and one young and the female *Triatoma* were dead even though the *Peromyscus* were alive when checked at Bakersfield.

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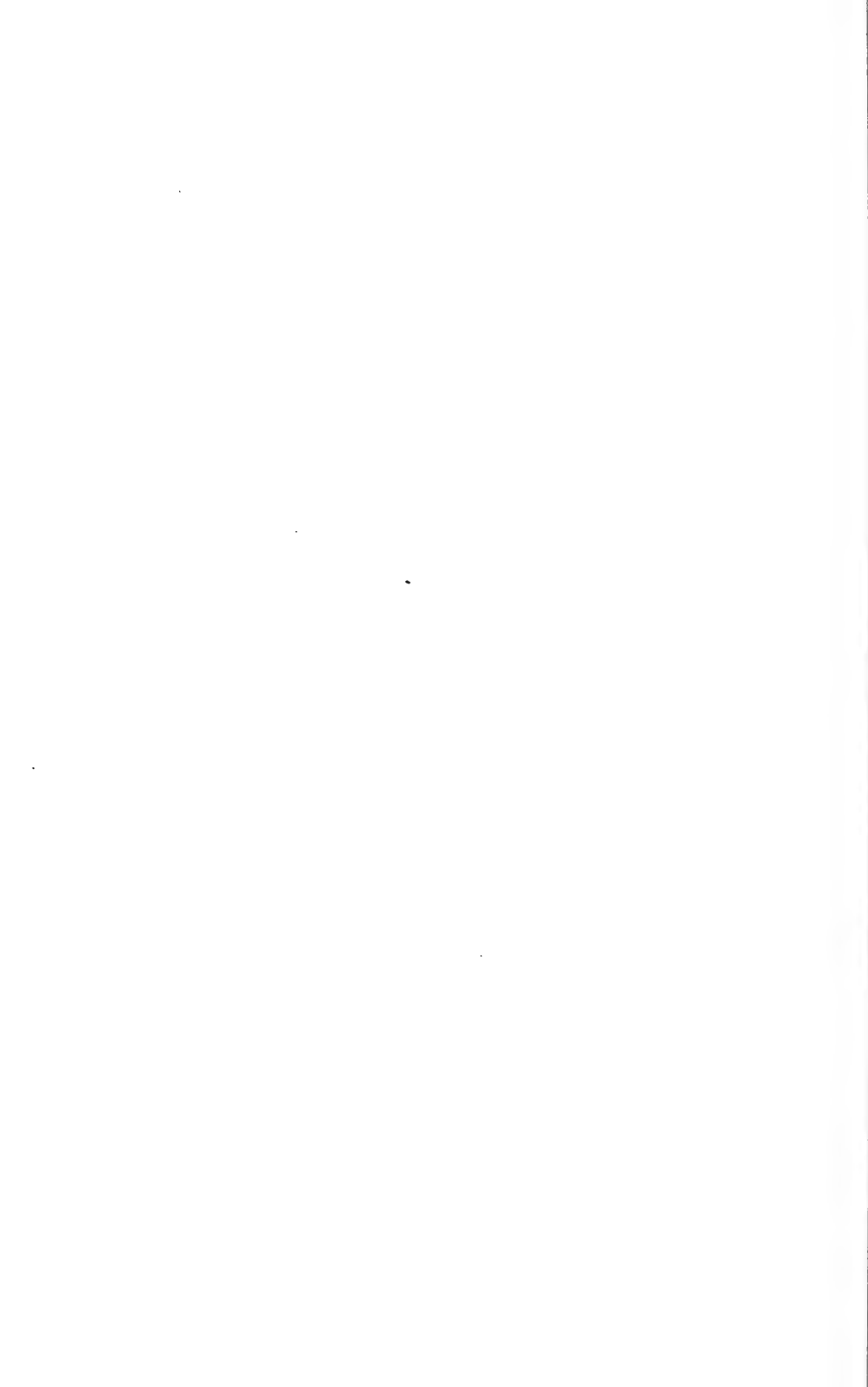
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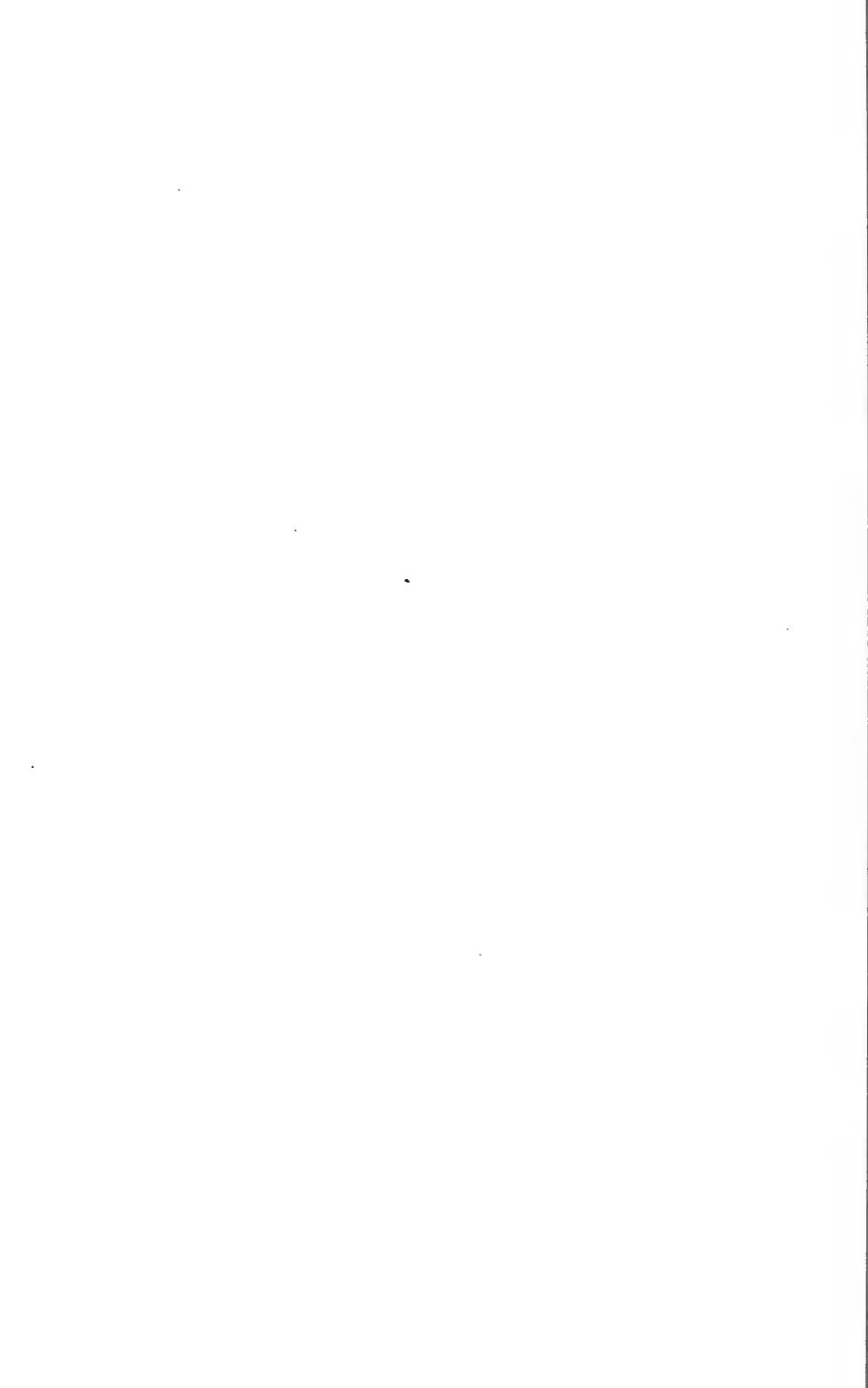


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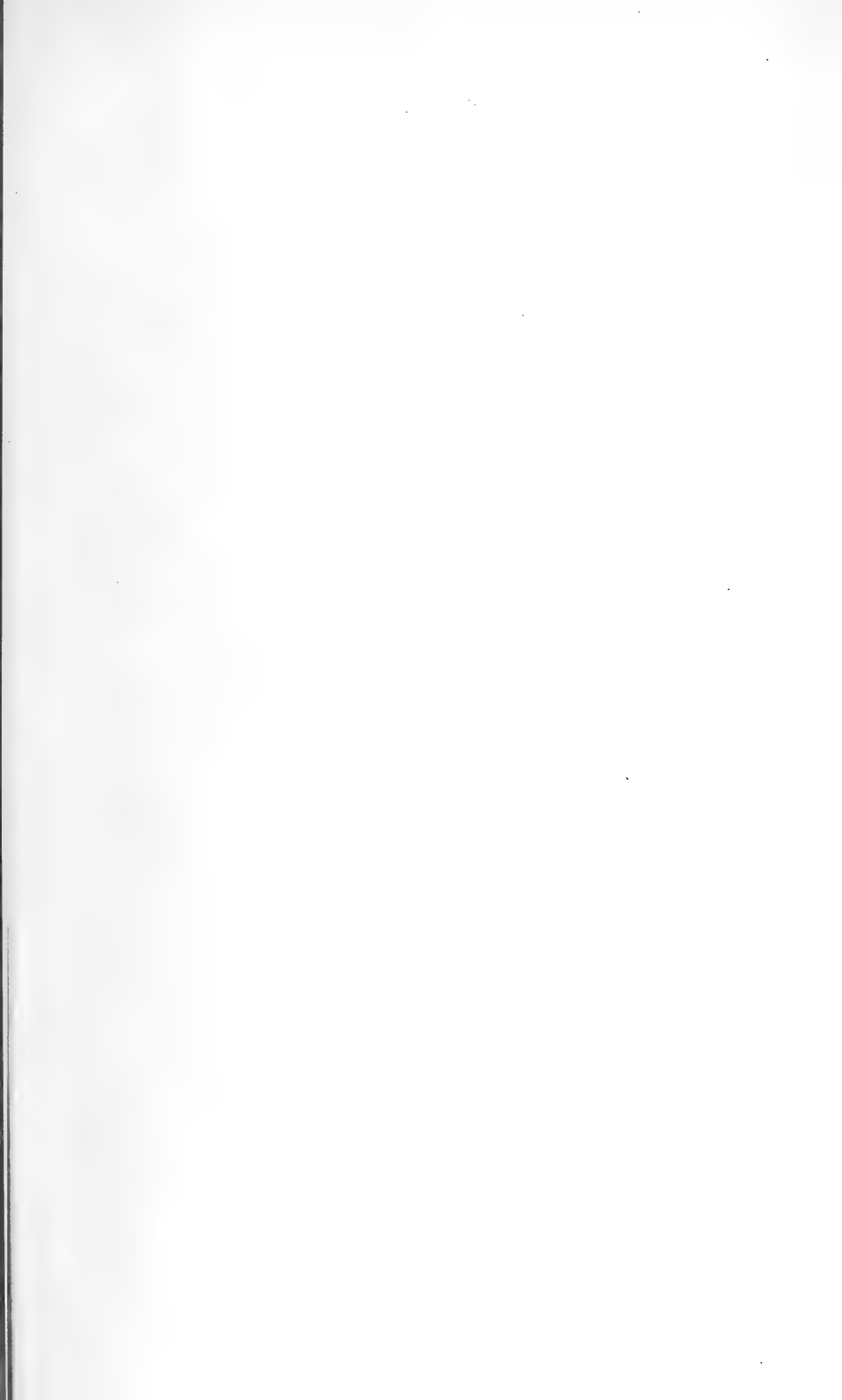


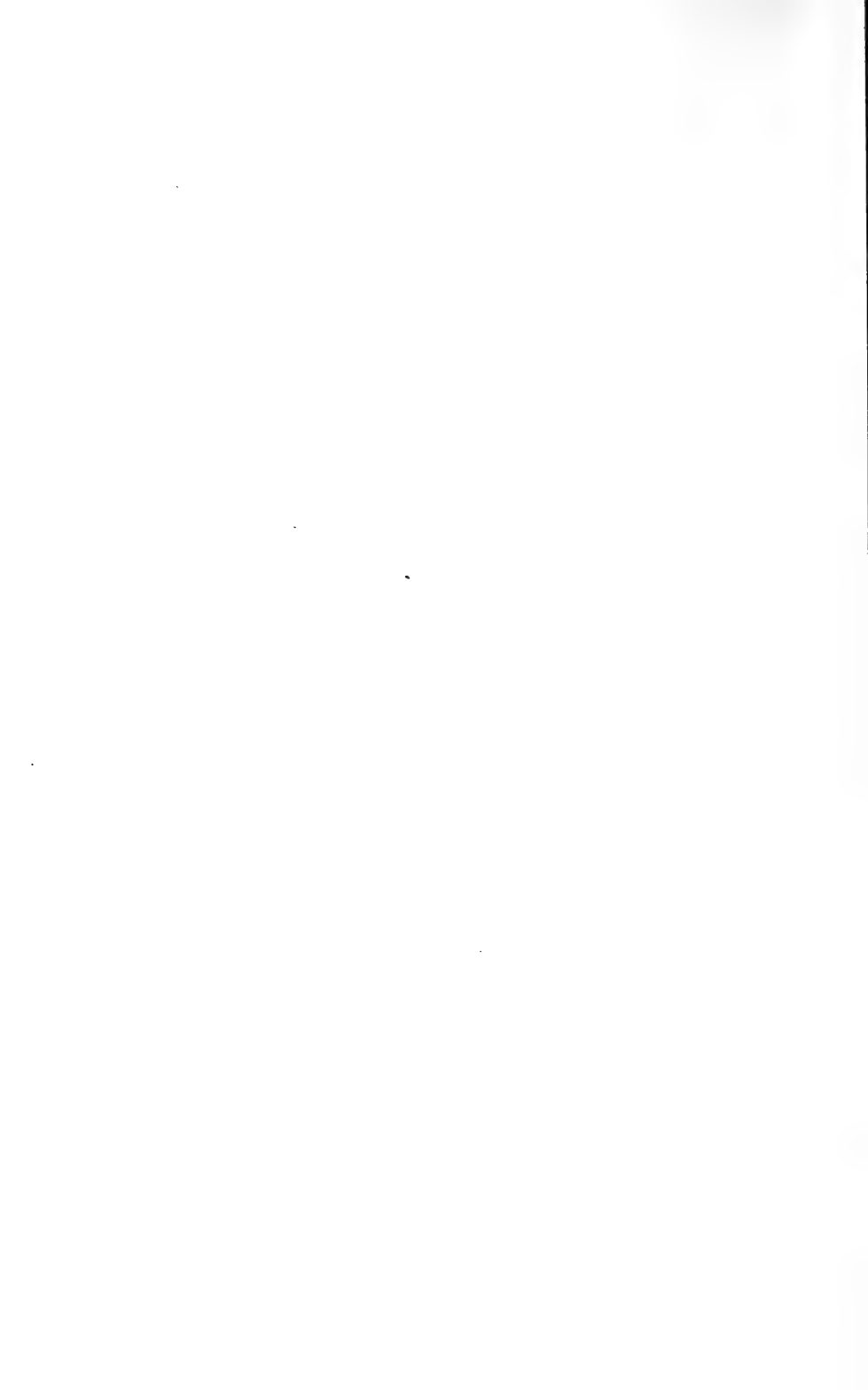
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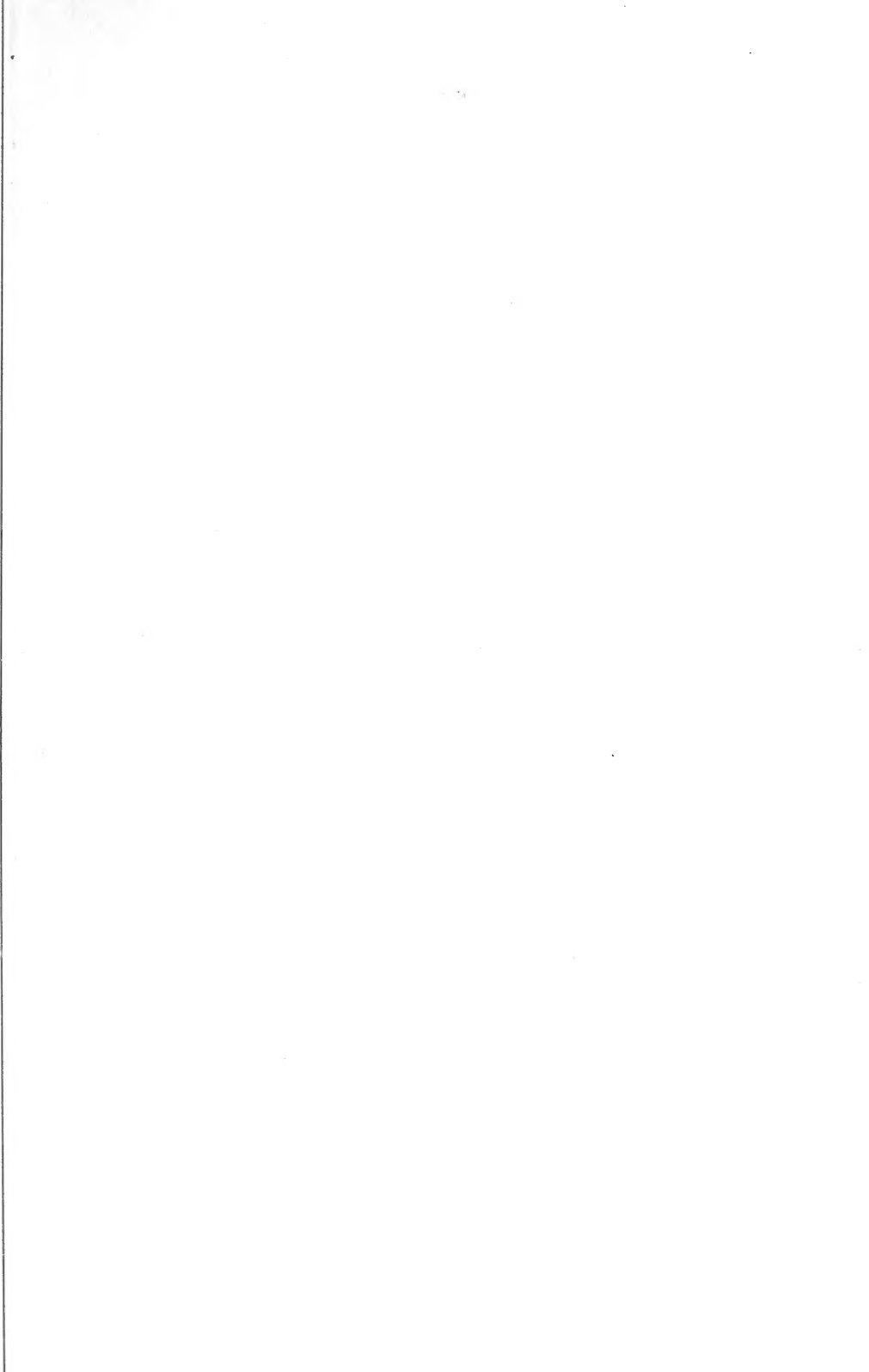


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